Rogers' Rangers Bridge Replacement

U.S. Department of Transportation

FOSTERING ADVANCEMENTS IN SHIPPING AND TRANSPORTATION FOR THE LONG-TERM ACHIEVEMENT OF NATIONAL EFFICIENCIES

"FASTLANE"

BENEFIT COST ANALYSIS

Project Name:	Rogers' Rangers Bridge Replacement Project
Project Type:	Bridge and Pedestrian/Snowmobile
Project Location:	Rural, Lancaster, New Hampshire and Guildhall, Vermont
Funds Requested:	$5,000,000 (43%)
Other State and Federal Funds	
New Hampshire:	$5,161,500 (45%)
Vermont:	$1,383,500 (12%)
Total Project Cost:	$11.5 million
Contact:	Mr. L. Robert Landry, Jr, P.E. Administrator Bureau of Bridge Design New Hampshire Department of Transportation 7 Hazen Drive, P.O. Box 483 Concord, New Hampshire 03302-0483 Telephone: 603-271-2731 Email: rlandry@dot.state.nh.us
DUNS #:	80-859-1697

Roger's Rangers Bridge Replacement Project

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1. Project Description

The U.S. Route 2 (Rogers' Rangers) Bridge over the Connecticut River is a two-span structure consisting of two 198' Parker Trusses connecting Lancaster, New Hampshire and Guildhall, Vermont for an overall length of 396'. The bridge was constructed in 1950 and provides two 12' travel lanes and two 2' wide shoulders for an overall roadway width of 28'. Traffic on the bridge is travelling along the areas only Principal Arterial route. The proposed replacement structure will consist of a welded steel plate girder bridge with a concrete deck and two equal spans of 200', for an overall length of 400'. The cross-section will consist of two 12' travel lanes, two 5' shoulders, and one 10' wide sidewalk for a rail-to-rail width of 44'.

This Benefit-Cost Analysis (BCA) was conducted to evaluate the replacement of the bridge compared to the base assumption, or "no build" alternative. The analysis considers the net societal benefits versus the net costs based upon criteria described in the FASTLANE *Benefit-Cost Analysis (BCA) Resource Guide* dated March 2016 that supplements the *2016 Benefit-Cost Analysis Guidance for Grant Applicants*. The analysis presented herein addresses benefits from travel time savings, user costs, emissions reduction and maintenance costs. Several additional benefits of the Rogers' Rangers Bridge replacement project are difficult to quantify but are regionally significant including economic competitiveness, livability enhancement, loss of connectivity and increase in response time for emergency vehicles due to the rural location of the project. Crash data was conservatively ignored in the analysis as there has only been one crash at the project location in the past 10 years, however, it could realistically be assumed that diverting heavy trucks along a 13-mile-long detour route could lead to additional crashes simply due to an increase in Vehicle-Miles-Traveled (VMT) on roads not designated as freight routes.

a. Base Case Assumption

The BCA cost analysis focuses on the replacement of the Rogers' Rangers Bridge, and compares the replacement project to the "no build" scenario, which is considered the base case assumption. The "no build" scenario assumes that the existing bridge would be maintained in service, with a "20 Ton" load limit posting in 2020 – when the structure reaches a 70 year service life. Similar structures in the region have suffered this fate. The posting does not completely close the bridge to traffic, only to heavy trucks with a Gross Vehicle Weight > 40,000 #'s. The spreadsheets and files pertinent to this BCA are referenced in the BCA spreadsheet and are included in the Appendices to this BCA narrative.

2. Project Benefits

a. User Costs

The Rogers' Rangers bridge is the only crossing of the Connecticut River between the towns of Lancaster, New Hampshire and Guildhall, Vermont and the shortest route to Interstate 91 and Interstate 93 in St. Johnsbury, Vermont. The next closest crossings for all vehicles are 13 miles to the north and 22 miles to the south. The shortest alternate route for freight is 13 miles to the north and utilizes a river crossing between Northumberland, New Hampshire and Guildhall, Vermont. Posting the bridge to a 20-ton capacity will cause diversion of all heavy truck travelling locally and regionally. So as to not over exaggerate the cost of traffic diversion, heavy truck traffic volume was estimated. In the absence of measured project specific heavy vehicle traffic, the analysis calculated the ratio of qualifying VMT to the total VMT statewide as measured by the California Air Resources Board. This ratio is 1.6% and presumed to be less than the actual volume since New Hampshire Department of Transportation's (NHDOT's) 2015 traffic data measured 10% trucks for all truck types. The Bureau of Transportation Statistics (BTS) provides additional supporting evidence that the ratio is not over exaggerated since wood products comprise greater than 10% by weight of all commodities originating in New Hampshire and 78% of all commodities are shipped by truck.

Yearly freight truck traffic increase in VMT is estimated to be 266,252 miles in 2015 and grows to 267,051 miles in 2020, the first year of the analysis. This increase in VMT is the result of 1.6% of the year 2015 3,500 Average Annual Daily Traffic (AADT) volume being detoured 13 miles to the next available river crossing suitable for freight traffic. For successive years beyond 2015, traffic volume is increased using a modest traffic growth factor of 0.1% per year.

2015 VMT	= 1.6% of Average Annualized Daily Traffic x Distance
	= 1.6% x 3500 x 365 days x 13 miles
	= 266,252

Under the same condition, the total change in Vehicle-Hours-Traveled (VHT) was estimated at an increase of 8,895 hours in 2020. This increase in VHT is due to the extended travel time required by 56 heavy trucks per day being detoured 13 miles travelling at 30 miles per hour as a result of seeking the next nearest available river crossing suitable for carrying freight traffic across the Connecticut River. Based upon speed limits on this alternate route, it is estimated that the detour will add an approximate 0.433 hours or 26 minutes per trip. Again for successive years beyond 2015, traffic volume is increased using a modest traffic growth factor of 0.1% per year.

2015 VHT	= 1.6% of Average Annualized Daily Traffic x Time per Trip
	= 1.6% x 3500 x 365 days x 0.433 hours
	= 8,850 VHT

The net changes in VHT per year were then multiplied by the hourly user costs of $24.90 to arrive at the yearly user costs. The net total annual user costs for the 50-year analysis are estimated to be an increase of $5,805,912 Net Present Value (NPV) in 2020 at a 3% discount for the base case scenario compared to the replacement alternative.

b. Safety

In comparison to the existing bridge, the replacement bridge will improve safety for all users. Specifically, the existing 28' wide roadway will be widened to 34' (providing 12' lanes, 5' shoulders, and a 10' snowmobile/sidewalk), thereby, improving safety for motorists, bicyclists and pedestrians. With regard to freight, the limited vertical clearance of 14'-0" of the existing bridge causes issues for trucks, particularly logging trucks. The portal bracing is routinely impacted by the freight, and there are numerous documented instances where logs end up on the concrete bridge deck, creating safety hazards for the operators of the trucks and other users of the bridge.

The existing bridge is the only connection between Lancaster, New Hampshire and Guildhall, Vermont. The Weeks Medical Facility in Lancaster is the nearest medical facility to several towns in eastern Vermont, as the next closest facility is the Littleton Regional Health Facility in Littleton, New Hampshire, 18 miles further north. Under the "no build" or base case scenario, emergency vehicles may eventually be required to detour around the bridge to reach this facility from eastern Vermont towns. This would lead to a 26-minute increase in emergency response time in each direction to the Weeks Medical Facility. Although this impact cannot easily be quantified in the BCA, the increased emergency response time would have significant effects on medical health issues where response time is critical.

The cost of safety relative to any increase in accidents arising out of the diversion of traffic onto more local roadway facilities was not quantified and monetized in the BCA.

c. State of Good Repair

The 50 year NPV (3%) of capital and maintenance costs for continued operation of the existing truss bridge is $5,908,368. This number was derived from actual costs documented by NHDOT and Vermont Agency for Transportation (VTrans) from 1974 through 2012 as well as anticipated capital and increased maintenance costs anticipated in the 50-year analysis period. These costs are anticipated to continue to keep the bridge in a state of good repair and open to all but heavy trucks. These capital and maintenance costs will not indefinitely allow freight traffic to continue to utilize the bridge. Therefore, these costs are included in the "no build" alternative as Benefits (Avoided Cost Associated with Alternate Route).

d. Sustainability

The "no build" alternative increases exhaust emissions due to the increase in VMT for freight traffic required to utilize the alternative route due to the 20-ton load posting of the bridge. The net emission savings have been calculated for Particulate Matter (PM), Nitrogen Oxides (NOx), and Carbon Dioxide (CO2). The calculations are based upon emissions factors that were applied to the "no build" alternative assuming that the bridge replacement alternative maintains a consistent level of emissions to the current condition with the existing bridge open to all traffic, including freight. Data is not available for Volatile Organic Compounds (VOC) or Sulfur Dioxide (Sox) emissions.

Based upon the annual VMT approximately 483 metric tons of CO2, 1.187 metric tons of NOX and 0.0042 metric tons of PM are avoided in the year 2020 with the replacement alternative. These emissions amount to a total monetized value of approximately $34,166 in the year 2020 and $51,879 in the year 2070. The cost of carbon in CO2 emissions has been calculated in the BCA spreadsheet using the Social Cost of Carbon (3% SCC 2015) values provided in the *Benefit-Cost Analysis (BCA) Resource Guide* dated March 2016 with reference to the "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866". An escalation in values within the CO2 portion of the exhaust emissions cost increases was utilized based on the Cost Performance Index (CPI) data to 2016 values. The net present value of air emissions costs is $1.11 million at the 3% discount rate and $ .559 million at the 7% discount rate.

3. Project Costs

The BCA assumes the replacement bridge project construction cost of $10 million. This cost does not include the Preliminary Engineering and Right-of-Way costs and only considers construction costs to be the future eligible costs under the FASTLANE grant program. The total project cost is assumed to be $11.5 million when considering all expended and future costs. Construction costs also include a minor expansion joint and minor repair of the replacement bridge ($45, 000) after 25 years and a full rehabilitation ($1,000,000) after 50 years. Maintenance and operation costs for the replacement structure are considered negligible (estimated at $2,500 every 10 years) but have been included in the BCA for completeness.

4. Conclusion

The annual benefits and cost values were discounted at 3% and 7% over a 50-year period. Three percent is considered the more appropriate rate for this analysis as the replacement bridge is expected to have a long service life, in excess of the 50-year period considered for the BCA. In addition, an alternate use of the funds would be for public expenditure rather than private investment which may have higher yields. The full analysis can be found in the spreadsheets in the appendices to this narrative. A summary of the results of the analysis are as follows:

Criteria	3% Discount Rate	7% Discount Rate
Total Benefits	$12.8 million	$8.03 million
Avoided Air Quality Impacts Value	$1.13 million	$0.56 million
Reduced User Costs	$5.81. million	$3.10. million
Avoided Maintenance Costs	$5.91 million	$3.96 million
Total Costs	$9.96 million	$9.39 million
Benefit-Cost Ratio (BCR)	1.29	.86

The avoided maintenance costs followed by the reduced user costs represent the largest portion of the total annual benefits. These cost savings are the most significant factors influencing the value of the BCR. Other costs savings, such as air quality and new structure maintenance have comparatively minimal influence on the overall value of the BCR.

5. Appendices

a. Bridge Alternatives Evaluation
b. NHDOT & VTrans Traffic Data
c. Benefit-Cost Analysis (BCA) Resource Guide 2016
d. Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866
e. RRBR Benefit-Cost Analysis Worksheet
    1. Average Emissions Factor Worksheet
    2. Emissions Reduction & VHT Worksheets
    3. RRBR Life Cycle O & M Cost Worksheet
    4. Truss Life Cycle O & M Worksheet
f. Bridge Inspection Report

Appendix A

Bridge Alternatives Evaluation

October 25, 2013

Hoyle, Tanner & Associates, Inc.
150 Dow Street
Manchester, New Hampshire 03101
603-669-5555
603-669-4168 fax
www.hoyletanner.com

Mr. L. Robert Landry, P.E.
Chief of Consultant Design
Bureau of Bridge Design
New Hampshire Department of Transportation
7 Hazen Drive / P.O. Box 483
Concord, NH 03302-0483

Attn: Mr. Joseph Adams, P.E.

Re: Lancaster, NH – Guildhall, VT A001(159), 16155
US Route 2 (Rogers' Rangers) Bridge over the Connecticut River
Bridge No. 111/129
Hoyle, Tanner Project No. 092558
Bridge Rehabilitation/Replacement Alternatives Analysis

Dear Mr. Landry:

Hoyle, Tanner and Associates, Inc. (Hoyle, Tanner) is pleased to submit this Bridge Rehabilitation/Replacement Alternatives Analysis letter report presenting the alternatives evaluated for the US Route 2 (Rogers' Rangers) Bridge over the Connecticut River. Bridge replacement is also being considered in addition to bridge rehabilitation due to the condition of the existing bridge, truck traffic volume and continually occurring vehicular impacts and damage due to inadequate vertical clearance of truss members above the bridge deck. A third alternative investigated includes bypassing the existing bridge with a new structure for vehicular use and retaining the existing bridge for recreational use only. This letter report includes the following enclosures:

- Truss Sections
- Bridge Bypass Alternative Truss Section
- Truss Elevation
- Bridge Replacement General Plan and Elevation
- Bridge Replacement Typical Section
- Evaluated Detour Routes
- Existing Bridge Alignment and Profile
- Bridge Rehabilitation Alternative Alignment and Profile
- Temporary Bridge Alignment and Profile
- Bridge Replacement Alternative Preferred Alignment and Profile
- Bridge Replacement Alternative Alignment Concepts
- Existing and Bridge Rehabilitation Alternative Roadway Typical Sections
- Temporary Bridge and Bridge Replacement Alternative Roadway Typical Sections
- Temporary Bridge Approach Roadway Critical Cross Sections
- Bridge Replacement Alternative Roadway Critical Cross Sections
- Engineer's Estimate of Probable Construction Costs

Existing Bridge

The existing bridge, constructed in 1950, is comprised of two (2) High Parker steel through trusses spaced at 35'-5½" with two (2) spans of 198'-0" each. The overall length of the bridge is 398'-0". Truss members consist of riveted built-up chords and rolled shape verticals and diagonals. The floor system consists of a variable depth reinforced concrete bridge deck within the travel lanes and a concrete filled steel grid within the shoulders supported by nine (9) rolled shape stringer lines and rolled shape floorbeams. Three (3) rolled beam shapes (18"x7½" WF 50#, 21"x8¼" WF 62# and 12¼"x6 5/8" WF 36#) and two (2) rolled beam shapes (36"x12" WF 160# and 36½"x12 1/8" WF 190#) were utilized for the stringer lines and floorbeams respectively. The bridge deck supports a 28'-0" roadway and two (2) 2'-6" open grid safety curbs.

According to the available design drawings, the reinforced concrete abutments are founded on six (6) 12" HP 53# steel bearing piles (3 vertical and 3 battered) driven under each truss bearing for a total of twelve (12) piles at each abutment. The reinforced concrete wall pier, which is battered ½" horizontal to 12" vertical from below the bearing seat to the top of footing, is supported by forty eight (48) 12" HP 74# steel bearing piles. Steel sheet piling was used as the pile cap concrete form and remains in place cut-off at a depth of approximately 5'-0" below the bottom of pile cap elevation.

A cantilevered sidewalk was added to the bridge in 1996 as part of a federal aid bridge enhancement project. The sidewalk also serves as a means for snowmobile users to cross the Connecticut River as part of the local trail system.

The bridge was considered to be in fair condition based on Hoyle, Tanner's September 2011 in-depth inspection findings. The bridge condition was downgraded to poor and it was added to the State's Redlist based on the NHDOT inspection performed on July 16, 2013. The following summarizes the 2011 in-depth observed deficiencies:

- Bridge deck cracking, spalling and leakage.
- Bridge deck pavement cracking.
- Safety curb open grid member section loss.
- Sidewalk timber deck weathering, rot and curled boards.
- Bridge rail deterioration.
- Extensive deterioration of floor system members.
- Truss bottom chord advanced deterioration and section loss. Significant pack rust between chord channels and side plates with deformation.
- Light to moderate top chord rusting.
- Lower half of truss diagonal members exhibit heavy rusting and deterioration on the side exposed to snow and salt spray.
- Truss vertical members damaged from vehicular impact on sway bracing members.
- Bent truss sway bracing members from vehicular impact due to inadequate vertical clearance above the bridge deck.
- Abutment and pier concrete cracking and spalling.

Our in-depth inspection program included concrete sampling and testing to determine compressive strength, chloride content, estimated air content and the presence of alkali silica reactivity (ASR). Concrete compressive strength test results ranged from 5870 psi to 6815 psi and 2860 psi to 3390 psi for the abutments and pier, respectively. Abutment water-soluble chloride content results indicate levels of chloride intrusion from 0.019 to 0.108 and 0.003 to

0.099 percent by weight at the New Hampshire and Vermont abutments, respectively. Pier water-soluble chloride content results indicate levels of chloride intrusion from 0.094 to 0.208 percent by weight.

The petrographic analysis results indicate that ASR is not present in the abutment samples tested; however, ASR is present in the pier. The ASR evidence within the pier sample is based on numerous cracks and microcracks filled with ASR gel. CTLGroup's report indicates the concrete core sample utilized for the petrographic analysis has been significantly deteriorated by ASR. The low concrete compressive strengths indicate this as well.

Estimated air content ranges from 3 to 5% and 1 to 3% for the New Hampshire and Vermont abutments, respectively. The pier estimated air content ranges from 3 to 5% in the sample tested.

Bridge Rehabilitation Alternative

Our inspection findings were used to perform a load rating for the existing superstructure in its as-inspected condition. A fatigue analysis and evaluation was performed to estimate the remaining service life of the bridge. The fatigue analysis indicates the bridge has an infinite fatigue service life since the maximum live load stress range is below the allowable fatigue stress range. The inspection findings, as-inspected load rating results, fatigue analysis and concrete testing results served as the basis for developing the bridge rehabilitation goal and recommendations.

A goal of the rehabilitation alternative is to repair or replace deteriorated truss and floor system members and gusset plates and increase the bridge's structural capacity to eliminate the need for a load posting (currently posted "E-1"). The HS20 design live load served as the basis for rehabilitation analysis and design. Our evaluation of rehabilitation alternatives included a comparison of the dead loads in the existing and rehabilitated conditions. Rehabilitation analysis results indicated that many members and connections would experience an increase of more than 15% in total load with a new cast-in-place reinforced concrete deck. Therefore consideration was given to the use of a lighter weight bridge deck alternative to reduce the dead load and maintain the total load imposed on the bridge as much as practicable. Improvement of the vertical clearance is also required due the volume and type of truck traffic that utilizes this bridge. The required rehabilitation measures are summarized below:

Truss Member Rehabilitation Measures

- Replace all lower panel point gusset plates at all bearings due to advanced deterioration and section loss.
- Replace all bottom chord members due to advanced deterioration, section loss and pack rust build-up between the member channels and side plates. Complete disassembly of the chord would otherwise be required to properly arrest pack rust build-up. This is not considered cost effective due to the presence of lead based paint and the level of deterioration.
- Replace south truss end diagonal member L0-U1 top plate: Plate is gouged and bent due to vehicular impact damage.
- Replace end diagonal channels exhibiting advanced deterioration and section loss. Advanced deterioration is located near connections rendering strengthening measures more difficult. Channel replacement is recommended for the following members:
    - Span 1 south truss member L0-U1 both channels

    - Span 1 north truss member L0-U1 north channel
    - Span 1 north truss member U8-L9 south channel
    - Span 2 south truss member U8-L9 both channels
    - Span 2 north truss member L0-U1 both channels
- Replacement of all end diagonal member lacing bars from mid-height to the bearing due to advanced deterioration and section loss.
- Replace Span 1 south truss diagonal member U5-L4: Member is fracture critical and has a gouge.
- Replace the following truss vertical members due to vehicular impact damage:
    - Span 1 south truss member L2-U2
    - Span 1 south truss member L3-U3
    - Span 1 north truss member L4-U4
    - Span 2 north truss member L3-U3
    - Span 2 south truss member L3-U3
    - Span 2 north truss member L4-U4
    - Span 2 south truss member L4-U4
    - Span 2 south truss member L5-U5
- Replace all bottom chord/floor system lateral bracing members and connection gusset plates due to condition.
- Connection rehabilitation by removing gusset plates, pack rust and scale and reinstalling plates at the following locations:
    - Span 1 south truss joints: L1, L2, L4, M45
    - Span 1 north truss joints: L2, M3, M4, L4, M45, M5, L7
    - Span 2 south truss joints: L4, L7
    - Span 2 north truss joints: L2, L3, M34, M45, M56, L7
- Gusset plate replacement due to extensive pack rust build-up causing permanent deformation at the following locations:
    - Span 1 south truss L7 north plate
    - Span 1 north truss L1 south plate
    - Span 2 north truss U4 north plate due to bent vertical member
- Replace all portal members and connections to increase vertical clearance from 14'-0" to 16'-6".
- Replace all sway bracing lower struts, diagonals, verticals and connection plates to increase vertical clearance from 14'-0" to 16'-6".
- Replace the following bent upper lateral bracing members:
    - Span 1 members U6S-U5N and U5N-U4S
    - Span 2 members U5S-U4N and U4S-U4N
- Blast clean and paint all existing structural steel to remain. Bridge is assumed to have lead paint.
- Use high-strength bolts for all member/connection replacements.
- Remove and replace missing or deteriorated rivets with high-strength bolts.

Truss Bearing Rehabilitation Measures

- Expansion Bearings: Replace all rocker bearings due to deterioration of curved bearing surface.
- Fixed Bearings: Blast clean the entire bearing assembly to bare metal and repaint. New fixed bearings will be required if cracks or significant deterioration on the pin bearing saddle surfaces is found.
- Bearing Pins:
    - Remove the retaining nuts and pins.

- Replace bearing pins and retaining nuts. Replacement is recommended based on past rehabilitation experience where existing pins had surface defects and section loss.
- Lightly grind and polish, by mechanical means, the saddle bearing surfaces.
- Coat the threaded portion of the pins and nuts with an anti-seize compound prior to assembly of the bearing pins and nuts.

Floor System Rehabilitation/Strengthening Measures

- Construct a new 5" Exodermic Bridge Deck™, with a ½" integral wearing surface, utilizing lightweight concrete, composite with the floorbeams and the stringers.
  - 1% crown is proposed for the replacement bridge deck to limit the required profile adjustment due to the increase in deck thickness.
  - A new 8" thick cast-in-place concrete deck and a new 5" Exodermic Bridge Deck™, utilizing normal weight concrete were evaluated but eliminated from further consideration due to the increased dead load imposed on the trusses.
- Replace all existing roadway stringers and connection angles due to condition. Replacement is more cost effective than repair and due to the presence of lead based paint.
- Replace all existing roadway floorbeams and connection angles. Existing floorbeams exhibit advanced section loss resulting in the need for the current "E-1" posting.
- Replace existing sidewalk timber decking with new nail-laminated timber decking.
  - An Exodermic Bridge Deck™ was evaluated but was eliminated from further consideration due to the increased dead load imposed on the north trusses.

Substructure Rehabilitation Measures

- Abutment Rehabilitation:
  - Remove and reconstruct a portion of the abutment backwalls to facilitate bearing pin and expansion joint removal and replacement.
  - Repair abutment and wingwall deteriorated and spalled concrete (estimated repair area is 225 sf).
- Pier rehabilitation versus replacement was evaluated. Replacement is recommended due to the following:
  - Significant areas of concrete spalling, scaling, surface abrasion delamination and map cracking on all faces.
  - Crack widths exceeding 1/16".
  - Crack depths below the waterline up to 3".
  - Exposed reinforcement exhibiting section loss.
  - Significant deterioration of concrete resulting from the presence of ASR. Low compressive strength test results when compared with abutment concrete strengths indicate this as well.

Miscellaneous Bridge Rehabilitation Items

- Replace existing bridge rail with T4 steel bridge rail which is recommended to protect truss members from vehicular impact.
- Replace existing expansion joints with new strip seal expansion joints.
- Retain the original cantilevered sidewalk rail posts, but replace the timber rail.
- Place additional stone fill protection at both abutments and all wingwalls.
- Construct new bridge approach rail, highway guardrail and terminal end units.

Bridge Bypass Alternative

Bypassing the existing bridge with a new vehicular bridge and retaining it for recreational use (i.e. pedestrians, snowmobiles, etc.) was evaluated to avoid the potential loss of a historic structure. Although the bridge would no longer carry vehicular traffic, rehabilitation is recommended prior to it being placed in service as a recreational structure for the following reasons:

- As previously mentioned, truss and floor system members have extensive deterioration and advanced section loss. Refer to the Existing Bridge Section of the report for the observed deficiencies.
- The bridge condition rating was recently downgraded from fair to poor.
- The bridge was added to the State's Redlist as a result if its condition and poor rating.
- AASHTO design loading for pedestrian structures is comparable to the HS20 design truck load, without the consideration of snow load.
- The bridge would no longer be subject to regular inspections once taken out of vehicular service.
- A long term funding source for continued maintenance and future rehabilitative work is not available.
- A "No-Build" approach does not address the structural deficiencies and the bridge will continue to deteriorate.

The rehabilitation goal for the bypass alternative is similar to that described in the Bridge Rehabilitation Alternative Section. Deteriorated truss and floor system members and gusset plates should be replaced in order to safely carry the required design loads and to allow the bridge to remain in service as a recreational structure for many years without concern for its condition and continued deterioration. The required rehabilitation measures for the bypass alternative are summarized below.

<u>Truss Rehabilitation Measures</u>

- All measures outlined in the Bridge Rehabilitation Alternative Section with the exception of the following:
  - Replacement of all portal members and connections to increase vertical clearance from 14'-0" to 16'-6".
  - Replacement of all sway bracing, lower strut, diagonal and vertical members and connection plates to increase vertical clearance from 14'-0" to 16"-6".
    - Straightening, repair or replacement of sway bracing members will likely be required where damaged main truss members are replaced.
  - Replacement of bent upper lateral bracing members.
    - Span 1 members U6S – U5N and U5N – U4S.
    - Span 2 members U5S – U4N and U4S – U4N.

<u>Truss Bearing Rehabilitation Measures</u>

- All measures outlined in the Bridge Rehabilitation Alternatives Section are recommended.

<u>Floor System Rehabilitation / Strengthening Measures</u>

- All measures outlined in the Bridge Rehabilitation Alternatives Section are recommended with the exception of the following:

  - Removal of the existing sidewalk deck and supporting measures is recommended since the sidewalk would no longer be required for recreational users.

<u>Substructure Rehabilitation Measures</u>

- Abutment rehabilitation and pier replacement is recommended for the reasons previously outlined.

<u>Miscellaneous Bridge Rehabilitation Items</u>

- Rehabilitate existing bridge rail.
- Replace existing expansion joints with new strip seal expansion joints.
- Place additional stone fill protection at both abutments and all wingwalls.

Bridge Replacement Alternative

The length of a new or replacement river crossing structure should be sized to provide adequate passage of water and sediment transport during different flow levels in accordance with the New Hampshire Stream Crossing Guidelines (Guidelines). The Connecticut River is defined as a Tier 3 Crossing since it is classified as a Designated River due to its values and characteristics and the drainage area is greater than one (1) square mile.

The Guidelines have a requirement, which is based on the stream type and entrenchment ratio, for adequately sizing a crossing. Based on FEMA Flood Insurance Rate Maps (FIRM), topographic maps and field observations, the bankfull width is estimated to be 300 feet and the flood prone width is 3000 feet. Based on these dimensions, the entrenchment ratio in the location of the existing bridge is ten (10) and the river is classified as a Type C stream. Therefore, a crossing length of 3000 feet is required to meet the Guidelines. However, NHDES rules allow for an alternative to be proposed if the design required to meet a specific rule stated within the Guidelines is not practicable.

Our review of the Lancaster, NH and Guildhall, VT Flood Insurance Studies (FIS) indicates the existing bridge is constructed within a regulatory floodway. Since the existing bridge is constructed within a regulatory floodway, which the current FIS is based on, and construction of a 3000 foot long bridge required to meet the Guidelines is not practicable due to cost and existing site conditions, a 400 foot long bridge was evaluated for the bridge replacement alternative. An in-depth hydrologic and hydraulic analysis will need to be performed to fully determine the impacts of a replacement bridge.

The proposed bridge replacement superstructure has an overall width of 47’-0” to accommodate two (2) 12’-0” travel lanes, two (2) 5’-0” shoulders and one (1) 10’-0” sidewalk. The increased sidewalk width is proposed to accommodate snowmobiles based on input at the initial Public Information Meeting held on November 8, 2012.

Two and three span layouts were evaluated for the proposed bridge replacement alternative to determine structure depths and roadway profile impacts. The two span bridge alternative evaluated has span lengths of 200’-0” each. The three span bridge alternative evaluated has span lengths of 120’-0”, 160’-0” and 120’-0”. Due to the span lengths under consideration, only structural steel welded plate girders were investigated. The two span bridge layout is preferred for the bridge replacement alternative since substructure costs and environmental impacts are minimized with construction of a single river pier. Preliminary structure depths, based on conceptual design, range from 63” to 105”. Refer to the proposed replacement bridge typical section drawing for additional information.

Traffic Control Alternatives

Bridge Rehabilitation

The following traffic control alternatives were investigated to accommodate traffic during bridge rehabilitation construction:

- Bridge closure with detour.
- Phased construction with one lane of signalized alternating one-way traffic.
- Temporary bridge supported by existing substructures.
- Temporary bridge located adjacent to the existing bridge.

Two (2) feasible detour options are available; one (1) to the north and one (1) to the south. The northerly detour route, which is approximately 13 miles in length, utilizes the crossing in Northumberland, NH and Guildhall, VT. The southerly detour route, which is approximately 22 miles in length, utilizes the crossing in Dalton, NH and Gilman, VT. A second southerly route is available, but it is not feasible as a detour since it includes crossing the Mount Orne timber covered bridge, which is posted with weight and vertical clearance restrictions. The Town of Lancaster provides mutual aid services to surrounding communities in Vermont via US Route 2 and the bridge is a major commerce corridor for the region. Additionally, this route is used by the communities of Lancaster and Guildhall for public school transportation and access to the hospital in Lancaster. Opposition to a road closure and detour was expressed by the communities during the Public Information Meetings held on November 8, 2012 and June 5, 2013. Therefore, the bridge closure with detour alternative was eliminated from further consideration for these reasons.

Phased construction with one lane of signalized alternating one-way traffic is not a feasible traffic control alternative due to the floor system and bottom chord replacement work required for the rehabilitation of this bridge. A temporary bridge supported by the existing substructures as a traffic control alternative is not feasible for the following reasons:

- The existing pier is in poor condition and replacement is recommended.
- The existing bridge would be closed and moved to an adjacent location to allow for constructing the temporary bridge.
- A second closure is required to remove the temporary bridge, move the trusses back into position and to complete the rehabilitation.
- Bridge closure for any period of time is not feasible.

Therefore, a temporary bridge located adjacent to the existing bridge is the preferred alternative for traffic control during bridge rehabilitation construction.

Bridge Replacement

Traffic is proposed to be maintained on the existing bridge during construction of a replacement bridge for the following reasons:

- Phased construction is not feasible with a truss bridge.
- Detour is not feasible for the reasons discussed above.

- The replacement bridge can be constructed offline which will reduce the overall project cost and construction duration since it can be completed in a single phase rather than multiple phases.

Roadway Design Criteria and Alternatives

Existing Conditions

The approach roadway consists of two (2) 12'-0" travel lanes, one (1) lane in each direction, and two (2) 4'-0" shoulders and has an overall width of 32'-0". Although the existing bridge has a sidewalk located outside the north trusses, there are no approach sidewalks within the project area. However, there is a snowmobile path on the north side of the bridge which extends approximately 100 feet to the west and east of the bridge.

The bridge is constructed on a tangent alignment and is located approximately 300 feet east of a "Y" intersection on the Vermont side. The Vermont approach has a 295 foot horizontal curve with a maximum superelevation rate of 7.5% and the New Hampshire approach is a tangent with normal crown. The US Route 2 profile has a 450 foot crest vertical curve, centered on the bridge, with approach entrance and exit tangent grades of 1.5% across the bridge. Although the posted speed limit on US Route 2 is 40 mph within the project area there are 25 mph warning signs posted for the horizontal curve in the northbound direction. The existing horizontal curve with a 284 foot inner radius and a maximum superelevation of 7.5% is adequate for 30 mph. The existing intersection configuration also has several conflict points which may be a potential safety issue.

Hoyle, Tanner performed a traffic analysis and determined the 2012 ADT's and truck percentages to be:

- US Route 2 east of the Connecticut River - 4,170 vehicles per day (vpd)
- US Route 2 and VT Route 102 west of the Connecticut River - 4,100 vpd
- VT Route 102 west of the Connecticut River (north of US Route 2) - 60 vpd
- US Route 2 truck percentage - 10%

Bridge Rehabilitation Alternative

The bridge rehabilitation alternative horizontal alignment will match the existing alignment. An upward profile adjustment of approximately 3" is required to accommodate the proposed bridge deck thickness. The approach roadway width will remain the same and will provide for two (2) 12'-0" travel lanes and two (2) 4'-0" shoulders. Normal crown transitioning to 1% cross slopes on the bridge is proposed for the rehabilitation roadway cross section.

Temporary Bridge

A temporary bridge and approaches is the preferred method of traffic control for the bridge rehabilitation alternative based on the considerations previously discussed. The proposed temporary bridge roadway 30 mph design speed was selected based on the topography surrounding the proposed temporary bridge location and evaluation of the roadway geometry. This will require temporarily down-posting the speed limit within the project area for construction safety.

The temporary bridge alternative roadway approaches consist of two (2) 12'-0" travel lanes and two (2) 3'-0" shoulders for a curb-to-curb width of 30'-0". A minimum approach roadway width of 30 feet is recommended to accommodate truck and emergency service vehicles due to horizontal curve radii. A 6'-0" wide sidewalk is proposed to accommodate snowmobiles and pedestrians on the temporary bridge.

The proposed location of the temporary bridge is north (upstream) of the existing bridge due to the proximity of several developed properties along the southern side of US Route 2. The proposed temporary bridge is located approximately 15 feet from edge of bridge to the centerline of the overhead utilities to provide sufficient separation for construction of the temporary bridge.

The proposed temporary bridge alignment is a tangent located between a horizontal curve with a radius of 325 feet and an 8 to 1 transition on the Vermont and New Hampshire approaches, respectively. The New Hampshire approach was designed to avoid impacts to a barn[1] located in the northeast quadrant of the project. Normal crown transitioning to zero percent (0%) at the temporary bridge is proposed for the temporary bridge approach roadway. Zero percent (0%) is recommended on the bridge so that cross slopes or crowns are not made by varying the bituminous overlay due to a concern of pavement shoving and rutting resulting from the high truck volume.

The proposed profile crosses the bridge at 0.5% increasing gradient from Vermont to New Hampshire. A 125 foot crest vertical curve with an exit grade of 3.55% and a 130 foot sag vertical curve with an exit grade of 0.19% are proposed at the New Hampshire approach to tie into existing US Route 2.

The temporary bridge roadway approaches are proposed to be constructed utilizing 2:1 side slopes. However, stabilized 1.5:1 side slopes could be utilized to minimize temporary slope impact limits.

<u>Bridge Replacement Alternative</u>

Location and Typical Section

The proposed location of the replacement bridge is north (upstream) of the existing bridge due to the proximity of several developed properties along the southern side of US Route 2. The proposed replacement bridge is located to provide a distance of approximately 15 feet from edge of bridge to the centerline of the overhead utilities to provide sufficient separation for construction of the bridge. The replacement bridge roadway approach is anticipated to consist of two (2) 12'-0" travel lanes and two (2) 5'-0" shoulders for a curb-to-curb width of 34'-0". A 10'-0" wide sidewalk/path is proposed for this alternative for snowmobile use and to match the replacement bridge sidewalk width.

[1] The barn is not considered to be historically significant based on an assessment performed by Suzanne Jamele for Historic Documentation Company in August 2013.

US Route 2 / VT Route 102 Intersection

Due to this alternative's new bridge location and the close proximity to the intersection of US Route 2 at VT Route 102, the roadway horizontal approaches to the bridge and the intersection configuration will need to be modified.

The following roadway layout alternatives were investigated for the intersection at US Route 2 and VT Route 102 for the proposed replacement bridge alternative:

- Alternative 1: "Y" configuration similar to the existing intersection
- Alternative 2: "T" intersection where US Route 2 "T's" into VT Route 102
- Alternative 3: Reconfigured "T" intersection where VT Route 102 "T's" into US Route 2 on a horizontal curve.

The conceptual plans for the viable alternatives investigated are included as an attachment.

The "Y" intersection alternative was developed to perpetuate the existing conditions with some improvements (flatter superelevation – 4% vs 7.5%, a larger horizontal curve – 328' vs 284' inner radius). This design results in a horizontal curve adequate for 30 mph similar to the existing condition. This alternative does not provide improvements to the potential safety issue relative to several conflict points.

Alternative 2 would require the traffic heading south on US Route 2, which includes a relatively high percentage of truck volume, to enter a "stop condition" to make the left turn. The "stop condition" is anticipated to create excessive delays; therefore, this alternative was eliminated from further consideration and is not included with the attachments. NHDOT concurred with eliminating this alternative at the Over the Shoulder (OTS) meeting held on October 2, 2013.

The reconfigured "T" intersection alternatives were further developed since the predominant traffic movement from the bridge is heading south on US Route 2, with a light volume of traffic (60 AADT) heading north on VT Route 102 and an effort to reduce conflict points. These alternatives propose one horizontal curve for US Route 2 to accommodate the predominant traffic movement and a "T" intersection for the VT Route 102 traffic. Horizontal curves adequate for 30 mph, 35 mph and 40 mph were investigated.

A horizontal curve with an inner radius of 533 feet and 4% superelevation is required for 40 mph. This curve has been shown on the 30 mph layout concept plan. The alignment significantly encroaches on the properties on the southerly/easterly side of US Route 2; therefore, no further investigation was performed for this alternative.

An inner radius of 371 feet with 4% superelevation is required for a horizontal curve adequate for 35 mph. The horizontal curve for this design extends onto the bridge; therefore, the superelevation transition would occur on a significant portion of the bridge. Based on AASHTO guidelines, this curve requires a lane width of 16 feet to accommodate the off-tracking of a WB-67 vehicle. The resulting pavement width for this design utilizing 5 foot shoulders is 42 feet (5'-16'-16'-5'). The pavement width transition and the off-tracking transition will occur on the bridge resulting in the need for a wider bridge. A preliminary review of the intersection sight distance indicates a potential permanent easement from the property on the southerly/easterly side of US Route 2 may be required with this design.

An inner radius of 250 feet with 4% superelevation is required for a horizontal curve adequate for 30 mph. The horizontal curve for this design ends approximately 60 feet west of the bridge. Based on AASHTO guidelines this curve requires a lane width of 18 feet to accommodate the off-tracking of a WB-67 vehicle. The resulting pavement width for this design utilizing 5 foot shoulders is 46 feet (5'-18'-18'-5'). The 60 foot tangent section before the bridge will allow the majority of pavement width transition, superelevation transition and off-tracking to occur prior to the bridge resulting in the need for a narrower bridge than the 35 mph alternative. A preliminary review of the intersection sight distance indicates no encroachment on adjacent properties.

As part of the design investigations, an Autoturn analysis was performed on the 30 mph and 35 mph curves using a WB-67 vehicle. The analysis indicated an off-tracking width of approximately 13.5 feet is required for each of the curves. As discussed with and supported by VTrans and NHDOT to minimize the bridge width and maintain a sufficient pavement width for WB-67 vehicles and bicyclists, a pavement layout of 14 foot lanes and 6 foot shoulders for the horizontal curve adequate for 30 mph is being offered as the preferred alternative. This lane configuration will allow the pavement width transition, the off-tracking transition and potentially all of the superelevation transition to occur before the bridge. The preferred lane configuration alternative is an improvement to the existing conditions.

Proposed Roadway Alignment and Profile

The replacement bridge will be constructed on a tangent alignment located between two horizontal curves with radii of 268 feet and 7200 feet at the Vermont and New Hampshire approaches, respectively. The New Hampshire approach curve connects to a reverse curve with a radius of 7200 feet to tie into the existing US Route 2. Using the AASHTO's superelevation table for e_{MAX} = 4%, the 7200 foot radii is more than adequate for the posted speed limit of 40 mph and is adequate for a design speed of 45 mph without superelevation. The barn, located in the northeast quadrant of the project, will be impacted by the proposed New Hampshire approach roadway alignment. Designs to avoid impacting this barn will result in adverse roadway approach geometry and will require a reduction in the design speed and permanent down posting of the speed limit in the project area.

The proposed replacement bridge profile has a 500 foot crest vertical curve with entrance (Vermont) and exit (New Hampshire) tangent grades of 2.04% and 2.73%, respectively, across the bridge. A 140 foot sag vertical curve with an entrance grade of 0.29% and an exit grade of 2.04% are proposed to tie the realigned US Route 2 into VT Route 102. A 280 foot sag vertical curve with an entrance grade of 2.73% and an exit grade of 0.93% are proposed at the New Hampshire approach to tie the realigned roadway into the existing US Route 2.

The bridge roadway approaches are proposed to be constructed utilizing 4:1 side slopes to minimize the guardrail length of need. However, 2:1, stabilized 1.5:1 side slopes and/or retaining walls could be utilized to minimize permanent slope impacts.

Utilities

Overhead utilities are adjacent to the existing roadway and bridge along the north side. The utility crosses US Route 2 approximately 600 feet east of the bridge, continuing along the south side towards the center of Lancaster. All alternatives under consideration were developed to allow the existing utilities to remain in their current locations; however, utility relocation may be identified as being required when the preferred alternative design is further advanced.

Estimates of Probable Construction Costs

The bridge rehabilitation cost estimate was prepared based on detailed quantity calculations due to the level of rehabilitation effort proposed and includes a 15% contingency. Temporary bridge rental is included for this estimate. Actual bridge rehabilitation construction costs may vary due to hidden deterioration exposed during the work.

The bridge replacement cost estimate was prepared based on conceptual level design and quantity calculations performed for this evaluation and includes a contingency of 15%.

Roadway construction costs are based on quantities determined from the conceptual design level plans. A summary of the roadway and bridge estimates of probable construction costs are provided below.

Bridge Rehabilitation

Bridge Rehabilitation:	$10,200,000
Temporary Bridge:	$3,000,000
Roadway:	$300,000
Temporary Approach Roadway:	$700,000
Total:	**$14,200,000**

Bridge Replacement

Bridge Replacement:	$7,500,000
Roadway:	$1,500,000
Bridge Removal:	$1,000,000
Total:	**$10,000,000**

Bridge Bypass

Bridge Rehabilitation:	$9,400,000
Bridge Replacement:	$7,500,000
Roadway:	$1,500,000
Total:	**$18,400,000**

Conclusion and Recommendation

The bridge rehabilitation and replacement alternatives investigated meet the goals of this project which is to address the structural deficiencies and increase the structural capacity to eliminate the need for a load posting.

Rehabilitation of the Rogers' Rangers Bridge for continued vehicular use is not recommended for the following reasons:

- Approximately 60% of the superstructure (truss members, floor system bracing and gusset plates) as well as the pier must be replaced in order to address the structural deficiencies and poor condition of the bridge.
- The bridge will not be designed for modern vehicular loads.
- The bridge will remain as the only vertical clearance limitation on US Route 2 in New Hampshire.

- The bridge could again be subject to vehicular impacts and load posting restrictions as truck dimensions and weights continue to increase.
- Snowmobiles would still not be able to pass side by side on the bridge.
- This alternative is the second highest in initial construction cost.
- Estimated service life is between 40 and 60 years.

Bypassing the existing bridge with a new vehicular bridge and retaining it for recreational use is not recommended for the following reasons:

- It increases environmental impacts.
- Is the most costly alternative.
- A long-term funding source for continued maintenance and future rehabilitation is not available.

Therefore, bridge replacement with removal of the existing structure is recommended. Bridge replacement offers the following:

- Structure which carries modern design loads.
- Eliminates only the vertical clearance limitation on US Route 2 within New Hampshire.
- Weathering steel superstructure for increased service life.
- Least initial construction cost and long-term maintenance costs.
- Traffic will be maintained on the existing bridge during construction thereby reducing cost.
- Alternative provides a 10’-0” sidewalk to accommodate passing snowmobiles.
- Least construction duration.
- Estimated service life is between 75 and 100 years.

We trust that this submittal will meet with the Departments approval and look forward to advancing bridge replacement as the preferred alternative design in further detail. Please feel free to contact me should you need any additional information or if you have any questions during your review of this submittal.

Sincerely
Hoyle, Tanner & Associates, Inc.

Ed Weingartner

Edward G. Weingartner, P.E.
Project Manager

Enclosures

Hoyle, Tanner & Associates, Inc.	Hoyle, Tanner & Associates, Inc. 150 Dow Street Manchester, NH 03101 (603) 669	Calc. By:	EGW	Date:	1/2/2013
		Chck. By:	EGW	Date:	9/5/2013
		Chck. By:		Date:	
		Chck. By:		Date:	

US Route 2 (Rogers' Rangers) Bridge over the Connecticut River, NHDOT Br. No. 111/129

Engineers Estimate of Probable Construction Costs

Hoyle, Tanner Project No. 092558/NHDOT Project No. 16155

Bridge Rehabiltation

ITEM NO	ITEM DESCRIPTION	Quantity		Cost	
		Unit	Amount	Unit	Total
209.201	GRANULAR BACKFILL (BRIDGE) (F)	CY	85	$50.00	$4,250
500.02	ACCESS FOR BRIDGE CONSTRUCTION	U	1	$200,000.00	$200,000
500.022	ACCESS FOR TEMPORARY BRIDGE CONSTRUCTION	U	1	$200,000.00	$200,000
501.1	TEMPORARY BRIDGE	U	1	$2,800,000.00	$2,800,000
502	REMOVAL OF EXISTING BRIDGE STRUCTURE	U	1	$1,300,000.00	$1,300,000
503.201	COFFERDAMS	U	1	$100,000.00	$100,000
504.1	COMMON BRIDGE EXCAVATION (F)	CY	210	$50.00	$10,500
512.0101	PREPARATION FOR CONCRETE REPAIRS, CLASS I	SY	25	$500.00	$12,500
520.01	CONCRETE CLASS AA	CY	10	$1,200.00	$12,000
520.12	CONCRETE CLASS A, ABOVE FOOTINGS (F)	CY	320	$750.00	$240,000
520.21	CONCRETE CLASS B, FOOTINGS (F)	CY	120	$350.00	$42,000
520.7001	LIGHTWEIGHT CONCRETE BRIDGE DECK (F)	CY	270	$900.00	$243,000
534.3	WATER REPELLENT (SILANE/ SILOXANE)	GAL	120	$75.00	$9,000
538.2	BARRIER MEMBRANE, PEEL AND STICK - VERTICAL SURFACES (F)	SY	25	$45.00	$1,125
541.5	PVC WATERSTOPS, NH TYPE 5 (F)	LF	35	$10.00	$350
544	REINFORCING STEEL (F)	LB	9000	$4.00	$36,000
544.2	REINFORCING STEEL, EPOXY COATED (F)	LB	90000	$2.00	$180,000
547	SHEAR CONNECTORS (F)	EA	5400	$5.00	$27,000
550.11	STRUCTURAL STEEL - BOTTOM CHORD (F)	LB	101000	$10.00	$1,010,000
550.12	STRUCTURAL STEEL - VERTICALS (F)	LB	12000	$12.00	$144,000
550.13	STRUCTURAL STEEL - DIAGONALS (F)	LB	1500	$12.00	$18,000
550.14	STRUCTURAL STEEL - END DIAGONALS (F)	LB	15500	$15.00	$232,500
550.15	STRUCTURAL STEEL - GUSSET PLATES (F)	LB	1000	$8.00	$8,000
550.16	STRUCTURAL STEEL - REHABILITATED GUSSET PLATES (F)	EA	19	$10,000.00	$190,000
550.17	STRUCTURAL STEEL - FLOOR FRAMING (F)	LB	354000	$5.00	$1,770,000
550.18	STRUCTURAL STEEL - UPPER BRACING (F)	LB	4500	$5.00	$22,500
550.189	STRUCTURAL STEEL - PORTAL AND SWAY BRACING (F)	LB	30500	$8.00	$244,000
550.19	TEMPORARY TRUSS SUPPORT SYSTEM	U	1	$375,000.00	$375,000
550.2	BRIDGE SHOES (F)	EA	4	$2,500.00	$10,000
552.1	REHABILITATION OF FIXED BRIDGE SHOES	EA	4	$2,000.00	$8,000
552.61	REPLACEMENT OF TRUSS BEARING PINS	EA	8	$2,000.00	$16,000
555.301	EXODERMIC STEEL BRIDGE DECK (F)	SF	13200	$40.00	$528,000
556.101	PAINTING EXISTING STRUCTURAL STEEL	U	1	$740,000.00	$740,000
556.201	CONTAINMENT AND ENVIRONMENTAL PROTECTION	U	1	$230,000.00	$230,000
556.301	WORKER PROTECTION	U	1	$37,000.00	$37,000
556.401	WASTE MANAGEMENT	U	1	$19,000.00	$19,000
561.11	PREFABRICATED EXPANSION JOINT, TYPE A (F)	LF	110	$520.00	$57,200
563.24	BRIDGE RAIL T4 (F)	LF	800	$200.00	$160,000
565.242	BRIDGE APPROACH RAIL T4 (STEEL POSTS)	U	4	$6,000.00	$24,000
568	STRUCTURAL TIMBER (F)	MBM	17	$6,000.00	$102,000
585.1	STONE FILL, CLASS A	CY	100	$40.00	$4,000
1002.1	REPAIRS OR REPLACEMENTS AS NEEDED - BRIDGE STRUCTURES	$	1	25,000	$25,000

	CONSTRUCTION (CON)
CONSTRUCTION SUBTOTAL	$11,391,925.00
CONTINGENCY (15%)	$1,708,788.75
CONSTRUCTION (CON) TOTAL FOR NHDOT FY PLANNING	**$13,200,000.00**

K:\092558\16155\Design\Estimates\[EstOfCost-Bridge Rehab.xls]Replacement

This Engineers Estimate of Probable Construction Costs is based on the anticipated scope of work, as well as HTA's experience with similar projects and understanding of current industry trends. The estimate has not been based on a final design for this project, and as such, it is intended to be preliminary in nature. It should be noted that changes in material or labor costs in the construction industry could impact the project cost in either direction.

Hoyle, Tanner & Associates, Inc. Hoyle, Tanner & Associates, Inc. 150 Dow Street Manchester, NH 03101 (603) 669	Calc. By:	EGW	Date:	9/5/2013
	Chck. By:		Date:	
	Chck. By:		Date:	
	Chck. By:		Date:	

US Route 2 (Rogers' Rangers) Bridge over the Connecticut River, NHDOT Br. No. 111/129

Engineers Estimate of Probable Construction Costs

Hoyle, Tanner Project No. 092558/NHDOT Project No. 16155

Bridge Bypass - Existing Bridge Rehabiltation

ITEM NO	ITEM DESCRIPTION	Quantity		Cost	
		Unit	Amount	Unit	Total
209.201	GRANULAR BACKFILL (BRIDGE) (F)	CY	85	$50.00	$4,250
500.02	ACCESS FOR BRIDGE CONSTRUCTION	U	1	$200,000.00	$200,000
502	REMOVAL OF EXISTING BRIDGE STRUCTURE	U	1	$1,200,000.00	$1,200,000
503.201	COFFERDAMS	U	1	$100,000.00	$100,000
504.1	COMMON BRIDGE EXCAVATION (F)	CY	210	$50.00	$10,500
512.0101	PREPARATION FOR CONCRETE REPAIRS, CLASS I	SY	25	$500.00	$12,500
520.01	CONCRETE CLASS AA	CY	10	$1,100.00	$11,000
520.12	CONCRETE CLASS A, ABOVE FOOTINGS (F)	CY	320	$750.00	$240,000
520.21	CONCRETE CLASS B, FOOTINGS (F)	CY	120	$350.00	$42,000
520.7001	LIGHTWEIGHT CONCRETE BRIDGE DECK (F)	CY	270	$900.00	$243,000
534.3	WATER REPELLENT (SILANE/ SILOXANE)	GAL	120	$75.00	$9,000
538.2	BARRIER MEMBRANE, PEEL AND STICK - VERTICAL SURFACES (F)	SY	25	$45.00	$1,125
541.5	PVC WATERSTOPS, NH TYPE 5 (F)	LF	35	$10.00	$350
544	REINFORCING STEEL (F)	LB	9000	$4.00	$36,000
544.2	REINFORCING STEEL, EPOXY COATED (F)	LB	90000	$2.00	$180,000
547	SHEAR CONNECTORS (F)	EA	5400	$5.00	$27,000
550.11	STRUCTURAL STEEL - BOTTOM CHORD (F)	LB	101000	$10.00	$1,010,000
550.12	STRUCTURAL STEEL - VERTICALS (F)	LB	12000	$12.00	$144,000
550.13	STRUCTURAL STEEL - DIAGONALS (F)	LB	1500	$12.00	$18,000
550.14	STRUCTURAL STEEL - END DIAGONALS (F)	LB	15500	$15.00	$232,500
550.15	STRUCTURAL STEEL - GUSSET PLATES (F)	LB	1000	$8.00	$8,000
550.16	STRUCTURAL STEEL - REHABILITATED GUSSET PLATES (F)	EA	19	$10,000.00	$190,000
550.17	STRUCTURAL STEEL - FLOOR FRAMING (F)	LB	354000	$5.00	$1,770,000
550.18	STRUCTURAL STEEL - UPPER BRACING (F)	LB	4500	$5.00	$22,500
550.189	STRUCTURAL STEEL - PORTAL AND SWAY BRACING (F)	LB	10000	$8.00	$80,000
550.19	TEMPORARY TRUSS SUPPORT SYSTEM	U	1	$375,000.00	$375,000
550.2	BRIDGE SHOES (F)	EA	4	$2,500.00	$10,000
552.1	REHABILITATION OF FIXED BRIDGE SHOES	EA	4	$2,000.00	$8,000
552.61	REPLACEMENT OF TRUSS BEARING PINS	EA	8	$2,000.00	$16,000
555.301	EXODERMIC STEEL BRIDGE DECK (F)	SF	13200	$40.00	$528,000
556.101	PAINTING EXISTING STRUCTURAL STEEL	U	1	$850,000.00	$850,000
556.201	CONTAINMENT AND ENVIRONMENTAL PROTECTION	U	1	$265,000.00	$265,000
556.301	WORKER PROTECTION	U	1	$43,000.00	$43,000
556.401	WASTE MANAGEMENT	U	1	$22,000.00	$22,000
561.11	PREFABRICATED EXPANSION JOINT, TYPE A (F)	LF	110	$520.00	$57,200
563.81	REHABILITATION OF BRIDGE RAIL (F)	LF	800	$175.00	$140,000
585.1	STONE FILL, CLASS A	CY	100	$40.00	$4,000
1002.1	REPAIRS OR REPLACEMENTS AS NEEDED - BRIDGE STRUCTURES	$	1	25,000	$25,000

	CONSTRUCTION (CON)
CONSTRUCTION SUBTOTAL	$8,134,925.00
CONTINGENCY (15%)	$1,220,238.75
CONSTRUCTION (CON) TOTAL FOR NHDOT FY PLANNING	**$9,400,000.00**

K:\092558\16155\Design\Estimates\[EstOfCost-Bridge Rehab.xls]Replacement

This Engineers Estimate of Probable Construction Costs is based on the anticipated scope of work, as well as HTA's experience with similar projects and understanding of current industry trends. The estimate has not been based on a final design for this project, and as such, it is intended to be preliminary in nature. It should be noted that changes in material or labor costs in the construction industry could impact the project cost in either direction.

Hoyle, Tanner & Associates, Inc.	Hoyle, Tanner & Associates, Inc. 150 Dow Street Manchester, NH 03101 (603) 669	Calc. By:	EGW	Date:	10/24/2013
		Chck. By:		Date:	
		Chck. By:		Date:	
		Chck. By:		Date:	

US Route 2 (Rogers' Rangers) Bridge over the Connecticut River, NHDOT Br. No. 111/129

Engineers Estimate of Probable Construction Costs

Hoyle, Tanner Project No. 092558/NHDOT Project No. 16155

Bridge Replacement

ITEM NO	ITEM DESCRIPTION	Quantity		Cost	
		Unit	Amount	Unit	Total
209.201	GRANULAR BACKFILL (BRIDGE) (F)	CY	600	$45.00	$27,000
403.11	HOT BITUMINOUS PAVEMENT, MACHINE METHOD	TON	135	$100.00	$13,500
403.911	HOT BITUMINOUS BRIDGE PAVEMENT, 1" BASE COURSE (F)	TON	90	$200.00	$18,000
500.02	ACCESS FOR BRIDGE CONSTRUCTION	U	1	$200,000.00	$200,000
502	REMOVAL OF EXISTING BRIDGE STRUCTURE	U	1	$1,000,000.00	$1,000,000
503.201	COFFERDAMS	U	1	$50,000.00	$50,000
504.1	COMMON BRIDGE EXCAVATION (F)	CY	440	$30.00	$13,200
508	STRUCTURAL FILL	CY	80	$40.00	$3,200
509.1	MOBILIZATION AND DEMOBIL OF DRILLED SHAFT DRILLING EQUIPMENT	U	1	$325,000.00	$325,000
509.2	DRILLED SHAFT	LF	260	$1,200.00	$312,000
509.3	OBSTRUCTION REMOVAL	LF	25	$2,000.00	$50,000
509.4	ROCK SOCKET EXCAVATION	LF	60	$3,000.00	$180,000
509.501	CROSSHOLE SONIC LOGGING (CSL) TESTS	EA	4	$1,000.00	$4,000
509.62	DRILLED SHAFT REINFORCING STEEL	LB	55000	$1.50	$82,500
510.1	PILE DRIVING EQUIPMENT	U	1	$100,000.00	$100,000
510.61	FURNISHING & DRIVING STEEL BEARING PILES	LB	200200	$1.00	$200,200
510.65	DRIVING-POINTS FOR STEEL BEARING PILES	EA	74	$225.00	$16,650
510.9	PILE SPLICES	EA	37	$125.00	$4,625
520.02	CONCRETE CLASS AA, ABOVE FOOTINGS (F)	CY	300	$1,100.00	$330,000
520.0302	CONCRETE CLASS AA, APPROACH SLABS (QC/QA) (F)	CY	65	$375.00	$24,375
520.12	CONCRETE CLASS A, ABOVE FOOTINGS (F)	CY	500	$600.00	$300,000
520.21	CONCRETE CLASS B, FOOTINGS (F)	CY	200	$350.00	$70,000
520.7002	CONCRETE BRIDGE DECK (QC/QA) (F)	CY	710	$850.00	$603,500
534.3	WATER REPELLENT (SILANE/ SILOXANE)	GAL	200	$75.00	$15,000
538.2	BARRIER MEMBRANE, PEEL AND STICK - VERTICAL SURFACES (F)	SY	50	$50.00	$2,500
538.5	BARRIER MEMBRANE, HEAT WELDED (F)	SY	1525	$30.00	$45,750
541.4	PVC WATERSTOPS, NH TYPE 4 (F)	LF	100	$10.00	$1,000
541.5	PVC WATERSTOPS, NH TYPE 5 (F)	LF	100	$10.00	$1,000
544	REINFORCING STEEL (F)	LB	90500	$1.00	$90,500
544.2	REINFORCING STEEL, EPOXY COATED (F)	LB	170000	$1.50	$255,000
544.7	SYNTHETIC FIBER REINFORCEMENT (F)	LB	445	$10.00	$4,450
547	SHEAR CONNECTORS (F)	EA	14420	$5.00	$72,100
548.21	ELASTOMERIC BEARING ASSEMBLIES (F)	EA	18	$2,500.00	$45,000
550.1	STRUCTURAL STEEL (F)	LB	1270000	$2.00	$2,540,000
561.301	PREFABRICATED EXPANSION JOINT, FINGER JOINT (F)	LF	47	$1,500.00	$70,500
561.302	PREFABRICATED EXPANSION JOINT, FINGER JOINT (F)	LF	47	$1,500.00	$70,500
563.22	BRIDGE RAIL T2 (F)	LF	403	$100.00	$40,300
563.24	BRIDGE RAIL T4 (F)	LF	403	$150.00	$60,450
565.222	BRIDGE APPROACH RAIL T2 (STEEL POSTS)	U	2	$5,000.00	$10,000
565.242	BRIDGE APPROACH RAIL T4 (STEEL POSTS)	U	2	$6,000.00	$12,000
585.21	STONE FILL, CLASS B (BRIDGE)	CY	275	$45.00	$12,375
593.231	GEOTEXTILE; SEPARATION CL. 3, NON-WOVEN	SY	400	$100.00	$40,000
1010.41	QUALITY CONTROL QUALITY ASSURANCE (QC/QA) FOR CONCRETE	$	1	15,000	$15,000

	CONSTRUCTION (CON)
CONSTRUCTION SUBTOTAL	$7,331,175.00
CONTINGENCY (15%)	$1,099,676.25
CONSTRUCTION (CON) TOTAL FOR NHDOT FY PLANNING	**$8,500,000.00**

K:\092558\16155\Design\Estimates\[EstOfCost-Bridge Rehab.xls]Replacement

This Engineers Estimate of Probable Construction Costs is based on the anticipated scope of work, as well as HTA's experience with similar projects and understanding of current industry trends. The estimate has not been based on a final design for this project, and as such, it is intended to be preliminary in nature. It should be noted that changes in material or labor costs in the construction industry could impact the project cost in either direction.

Hoyle, Tanner & Associates, Inc.

Date Printed: 10/25/2013

BRIDGE REHABILITATION

NHDOT NHDOT Project No. 16155

Bridge Rehabilitation/Replacement Alternatives Analysis HTA Project No. 092558

US Route 2 Over the Connecticuit River Date of Estimate: 1-2-2013

OPINION OF COST

QUANTITIES RELATED TO ROADWAY CONSTRUCTION Calc'd By: SCS Date: 1/2/2013

Checked By: JRM Date: 1/2/2013

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
203.1	COMMON EXCAVATION	CY	1,250.00	$ 10.00	$ 12,500.00
203.6	EMBANKMENT-IN-PLACE (F)	CY	60.00	$ 6.00	$ 360.00
214	FINE GRADING	U	1.00	$ 5,000.00	$ 5,000.00
304.2	GRAVEL (F)	CY	970.00	$ 20.00	$ 19,400.00
304.3	CRUSHED GRAVEL (F)	CY	970.00	$ 25.00	$ 24,250.00
403.11	HOT BITUMINOUS PAVEMENT, MACHINE METHOD	TON	650.00	$ 85.00	$ 55,250.00
403.12	HOT BITUMINOUS PAVEMENT, HAND METHOD	TON	7.00	$ 110.00	$ 770.00
417	COLD PLANING BITUMINOUS SURFACES	SY	520.00	$ 3.00	$ 1,560.00
606.12	BEAM GUARDRAIL (STANDARD SECTION) (STEEL POST)	LF	630.00	$ 18.00	$ 11,340.00
606.1255	BEAM GUARDRAIL (TERM. UNIT TYPE EAGRT 25 FT) (STEEL POST)	U	4.00	$ 1,600.00	$ 6,400.00
608.13	3" BITUMINOUS SIDEWALK (F)	SY	700.00	$ 17.00	$ 11,900.00
609.01	STRAIGHT GRANITE CURB	LF	650.00	$ 20.00	$ 13,000.00
	SUBTOTAL A				**$ 161,730.00**
	MISC. ITEMS (MARKINGS, LOAM, SEED, SIGNS) (15% SUB A)	15%			$ 24,259.50
	SUBTOTAL B				**$ 185,989.50**
	DRAINAGE ITEMS (25% SUB B)	25%			$ 46,497.38
	SUBTOTAL C				**$ 232,486.88**
619.1	MAINTENANCE OF TRAFFIC	U	1	$ 10,000.00	$ 10,000.00
	MISC. TRAFFIC CONTROL (VMS, IMPACT ATTEN) (55% of 619.1)	U	1	$ 5,500.00	$ 5,500.00
	EROSION, SEDIMENT, AND POLLUTION CONTROL (10% DRAINAGE)	U	1.00	$ 4,649.74	$ 4,649.74
	(HAY BALES, SILT FENCE, SWPPP, TEMP. WATER POLL. CONTROL)				
	SUBTOTAL D				**$ 237,136.61**
	ROADWAY MOBILIZATION	5%			$ 11,856.83
	ROADWAY CONTINGENCIES	10%			$ 23,713.66
	MISCELLANEOUS (LANDSCAPING, FUEL ADJUST., ALTERATIONS)	5%			$ 11,856.83
				Item Total:	**$ 284,563.94**
				SAY	**$ 300,000.00**

Hoyle, Tanner & Associates, Inc.

Date Printed: 10/25/2013

TEMPORARY ROAD - BRIDGE REHABILITATION

NHDOT NHDOT Project No. 16155

Bridge Rehabilitation/Replacement Alternatives Analysis HTA Project No. 092558

US Route 2 Over the Connecticuit River Date of Estimate: 1-2-2013

OPINION OF COST

QUANTITIES RELATED TO ROADWAY CONSTRUCTION Calc'd By: SCS Date: 1/2/2013

Checked By: JRM Date: 1/2/2013

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
201.1	CLEARING AND GRUBBING (F)	A	0.03	$ 10,000.00	$ 300.00
203.1	COMMON EXCAVATION	CY	1,700.00	$ 10.00	$ 17,000.00
203.6	EMBANKMENT-IN-PLACE (F)	CY	6,690.00	$ 6.00	$ 40,140.00
214	FINE GRADING	U	1.00	$ 10,000.00	$ 10,000.00
304.2	GRAVEL (F)	CY	2,130.00	$ 20.00	$ 42,600.00
304.3	CRUSHED GRAVEL (F)	CY	2,130.00	$ 25.00	$ 53,250.00
304.35	CRUSHED GRAVEL FOR DRIVES	CY	100.00	$ 25.00	$ 2,500.00
403.11	HOT BITUMINOUS PAVEMENT, MACHINE METHOD	TON	1,525.00	$ 85.00	$ 129,625.00
403.12	HOT BITUMINOUS PAVEMENT, HAND METHOD	TON	105.00	$ 110.00	$ 11,550.00
417	COLD PLANING BITUMINOUS SURFACES	SY	785.00	$ 3.00	$ 2,355.00
606.12	BEAM GUARDRAIL (STANDARD SECTION) (STEEL POST)	LF	850.00	$ 18.00	$ 15,300.00
606.1255	BEAM GUARDRAIL (TERM. UNIT TYPE EAGRT 25 FT) (STEEL POST)	U	4.00	$ 1,600.00	$ 6,400.00
608.13	3" BITUMINOUS SIDEWALK (F)	SY	120.00	$ 17.00	$ 2,040.00
609.811	BITUMINOUS CURB, TYPE B (4" REVEAL)	LF	700.00	$ 10.00	$ 7,000.00
	SUBTOTAL A				**$ 340,060.00**
	MISC. ITEMS (MARKINGS, LOAM, SEED, SIGNS) (15% SUB A)	15%			$ 51,009.00
	SUBTOTAL B				**$ 391,069.00**
	DRAINAGE ITEMS (25% SUB B)	25%			$ 97,767.25
	SUBTOTAL C				**$ 488,836.25**
618.61	UNIFORMED OFFICERS WITH VEHICLE	$	1	$ 24,000.00	$ 24,000.00
619.1	MAINTENANCE OF TRAFFIC	U	1	$ 30,000.00	$ 30,000.00
606.417	PORTABLE CONCRETE BARRIER FOR TRAFFIC CONTROL	LF	500.00	$ 25.00	$ 12,500.00
	MISC. TRAFFIC CONTROL (VMS, IMPACT ATTEN) (55% of 619.1)	U	1	$ 16,500.00	$ 16,500.00
	EROSION, SEDIMENT, AND POLLUTION CONTROL (10% DRAINAGE)	U	1.00	$ 9,776.73	$ 9,776.73
	(HAY BALES, SILT FENCE, SWPPP, TEMP. WATER POLL. CONTROL)				
	SUBTOTAL D				**$ 581,612.98**
	ROADWAY MOBILIZATION	5%			$ 29,080.65
	ROADWAY CONTINGENCIES	10%			$ 58,161.30
	MISCELLANEOUS (LANDSCAPING, FUEL ADJUST., ALTERATIONS)	5%			$ 29,080.65
				Item Total:	**$ 697,935.57**
				SAY	**$ 700,000.00**

NHDOT | NHDOT Project No. 16155
PROPOSED ROADWAY (BRIDGE REPLACEMENT) | HTA Project No. 92558
US RTE 2 Over the Connecticut River | Date of Estimate: 10/24/2013
OPINION OF COST
QUANTITIES RELATED TO ROADWAY CONSTRUCTION | Calc'd By: SCS | Date: 12/12/2012
Checked By: CED | Date: 10/24/2013

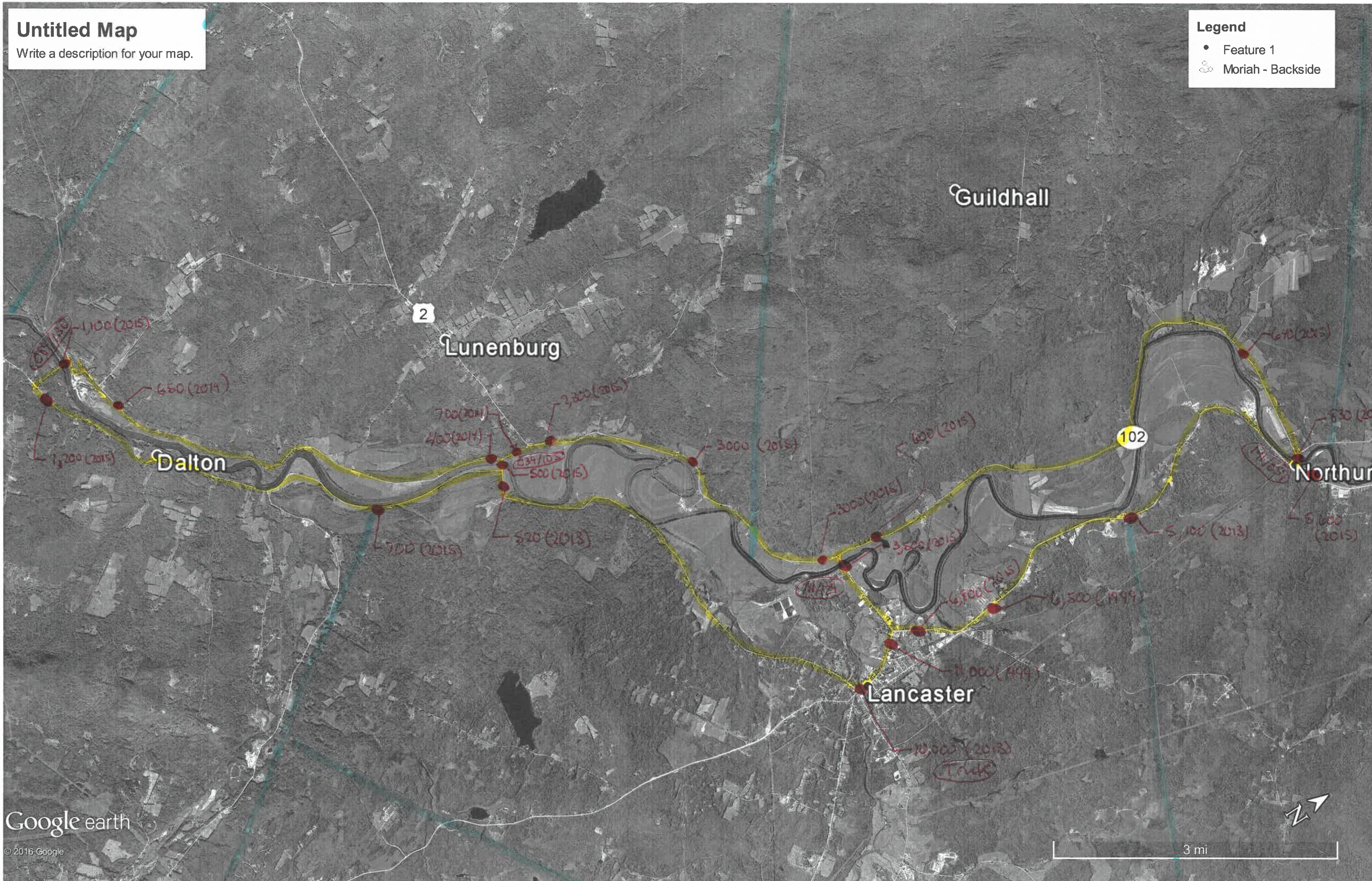
ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
201.1	CLEARING AND GRUBBING (F)	A	0.04	$ 10,000.00	$ 400.00
202.2	DEMOLISHING BUILDINGS	U	1.00	$ 25,000.00	$ 25,000.00
203.1	COMMON EXCAVATION	CY	5,700.00	$ 10.00	$ 57,000.00
203.6	EMBANKMENT-IN-PLACE (F)	CY	13,700.00	$ 6.00	$ 82,200.00
214	FINE GRADING	U	1.00	$ 15,000.00	$ 15,000.00
304.1	SAND (F)	CY	4,200.00	$ 16.00	$ 67,200.00
304.35	CRUSHED GRAVEL FOR DRIVES	CY	320.00	$ 35.00	$ 11,200.00
304.4	CRUSHED STONE (FINE GRADATION) (F)	CY	2,100.00	$ 25.00	$ 52,500.00
304.5	CRUSHED STONE (COARSE GRADATION) (F)	CY	2,100.00	$ 22.00	$ 46,200.00
403.11	HOT BITUMINOUS PAVEMENT, MACHINE METHOD	TON	4,100.00	$ 85.00	$ 348,500.00
403.12	HOT BITUMINOUS PAVEMENT, HAND METHOD	TON	350.00	$ 110.00	$ 38,500.00
417	COLD PLANING BITUMINOUS SURFACES	SY	300.00	$ 3.00	$ 900.00
606.12	BEAM GUARDRAIL (STANDARD SECTION) (STEEL POST)	LF	800.00	$ 18.00	$ 14,400.00
606.1255	BEAM GUARDRAIL (TERM. UNIT TYPE EAGRT 25 FT) (STEEL POST)	U	4.00	$ 1,600.00	$ 6,400.00
606.417	PORTABLE CONCRETE BARRIER FOR TRAFFIC CONTROL	LF	500.00	$ 25.00	$ 12,500.00
608.13	3" BITUMINOUS SIDEWALK (F)	SY	700.00	$ 21.00	$ 14,700.00
609.01	STRAIGHT GRANITE CURB	LF	800.00	$ 20.00	$ 16,000.00
				Subtotal:	$ 808,600.00

EROSION, SEDIMENT, AND POLLUTION CONTROL (HAY BALES, SILT FENCE, SWPPP, TEMP. WATER POLL. CONTROL)		5%	$ 40,430.00
MAINTENANCE OF TRAFFIC		10%	$ 80,860.00
MOBILIZATION (ROADWAY & BRIDGE - 7.5M + 1M)	8500000	5%	$ 425,000.00
ROADWAY CONTINGENCIES (UTILITY RELOCATIONS, DRAINAGE, LANDSCAPING, ETC)		10%	$ 80,860.00
MISCELLANEOUS (FUEL ADJUST., ALTERATIONS)		5%	$ 40,430.00

Item Total: $1,476,180.00
SAY $1,500,000.00

Appendix B

NHDOT & VTrans Traffic Data



Untitled Map
Write a description for your map.
Legend
Feature 1
Moriah - Backside
Guildhall
2
Lunenburg
Dalton
Lancaster
102
Northum
1,100 (2015)
650 (2014)
1,200 (2015)
700 (2014)
4,100 (2014)
2,300 (2015)
500 (2015)
520 (2013)
700 (2015)
3000 (2015)
600 (2015)
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3,500 (2015)
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11,000 (1999)
10,000 (2013)
5,100 (2013)
610 (2015)
830 (2013)
Truck
3 mi
Google earth
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STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION
BUREAU OF TRAFFIC

Bureau of Planning, Traffic Section, Traffic Reports

18-Feb-16

STAT.	TYPE	LOCATION	FC	2008	2009	2010	2011	2012	2013	2014	2015
Town: DALTON											
109050	82	BRIDGE HILL RD AT VERMONT SL	07	*	1300	*	*	1000	*	*	1100
109051	82	NH 135 (DALTON RD) EAST OF BRIDGE HILL RD	07	*	1100	*	*	920	*	*	1200
109052	82	NH 142 (WHITEFIELD RD) SOUTH OF SCOTT STATION RD	08	*	660	*	*	600	*	*	690
109053	82	NH 142 (WHITEFIELD RD) OVER BLACK BROOK	08	*	660	*	*	550	*	*	680
109054	82	FRENCH RD OVER JOHNS RIVER	09	*	270	*	*	200	*	*	230

STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION
BUREAU OF TRAFFIC

Bureau of Planning, Traffic Section, Traffic Reports

18-Feb-16

STAT.	TYPE	LOCATION	FC	2008	2009	2010	2011	2012	2013	2014	2015
Town: LANCASTER											
247052	62	US 2 (BRIDGE ST) AT VERMONT SL (EB-WB) (61247071-61247072)	02	*	3700	*	*	3800	*	*	3500
247053	62	US 3 (PROSPECT ST) AT WHITEFIELD TL	06	*	*	4800	*	*	4700	*	*
247054	62	NH 135 (ELM ST) EAST OF MT ORNE RD	07	*	*	530	*	*	520	*	*
247055	62	US 3 (MAIN ST) AT NORTHUMBERLAND TL	06	*	*	5800	*	*	5100	*	*
247056	82	MT ORNE RD OVER CONNECTICUT RIVER	07	*	480	*	*	590	*	*	500
247057	62	NH 135 (ELM ST) AT DALTON TL	07	*	690	*	*	640	*	*	700
247058	82	US 2/US 3 (MAIN ST) AT ISRAEL RIVER BRIDGE (EB-WB) (81247069-81247070)	02	9900	*	12000	*	*	10000	*	*
247059	82	US 3 (NO. MAIN ST) NORTH OF BRIDGE ST	06	*	6600	*	*	7000	*	*	6800
247061	82	NORTH RD WEST OF GRANGE RD	08	*	1800	*	*	1600	*	*	1700
247063	82	MECHANIC ST OVER ISRAEL RIVER	09	*	810	*	*	710	*	*	730
247064	82	GARLAND RD OVER OTTER BROOK	09	*	550	*	*	260	*	*	470
247065	82	NORTH RD EAST OF BROOK RD	08	*	570	*	*	580	*	*	560
247066	82	GARLAND RD OVER GARLAND BROOK	09	*	160	*	*	160	*	*	140
247067	82	MCGARY HILL RD OVER OTTER BROOK	09	*	130	*	*	100	*	*	110

STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION
BUREAU OF TRAFFIC

Bureau of Planning, Traffic Section, Traffic Reports

18-Feb-16

STAT.	TYPE	LOCATION	FC	2008	2009	2010	2011	2012	2013	2014	2015
Town: NORTHUMBERLAND											
347001	02	US 3 (STRATFORD RD) SOUTH OF BALL RD SOUTH INTERSECTION (SB-NB) (01347002-01347003)	06	3036	3015	2979	2790	2768	2759	2849	2900
347051	62	NH 110 (BERLIN-GROVETON HWY) SOUTH OF WEMYSS DR	06	*	1500	*	*	1900	*	*	2100
347052	82	US 3 (DANIEL WEBSTER HWY) NORTH OF GUILDHALL RD	06	*	5600	*	*	4900	*	*	5600
347053	82	GUILDHALL RD AT VERMONT SL	06	840	*	1100	*	*	830	*	*
347054	82	US 3 (MAIN ST) OVER UPPER AMMONOOSUC RIVER	06	*	*	5900	*	*	5200	*	*
347056	82	LOST NATION RD WEST OF HERMAN SAVAGE RD	08	*	*	340	*	*	330	*	*
347057	82	LOST NATION RD EAST OF ROARING BROOK DR	08	*	480	*	*	380	*	*	360

NO.	NAME	FC	TOWN	BEGINNING REFERENCE: MM	NAME	NUMBER	ENDING REFERENCE: MM	NAME	NUMBER	ATR STA	TYPE	2007 AADT	2011 AADT	2014 AADT
											ATR			
210	TH1 SHELBURNE FALLS RD	7	HINESBURG	0.000	SHELBURNE TL		2.960	VT 116	VT 116	D366		2700 A	2400 A	2300 A
211	TH4 GORE RD	7	STARKSBORO	0.000	VT 17	VT 17	0.910	BUEL'S GORE TL		A330	ATR	460 A	490 A	490 E
211	TH1 GORE RD	7	BUEL'S GORE	0.000	STARKSBORO TL		0.450	HUNTINGTON TL		D750		500 A	490 E	490 E
211	TH1 MAIN RD	7	HUNTINGTON	0.000	BUEL'S GORE TL		1.300	BEANE RD	TH-32			500 E	490 E	490 E
211	TH1 MAIN RD	7	HUNTINGTON	1.300	BEANE RD	TH-32	4.890	CAMELS HUMP RD	TH-4	D355	ATR	1100 A	1100 E	1100 E
211	TH1 MAIN RD	7	HUNTINGTON	4.890	CAMELS HUMP RD	TH-4	6.580	HINESBURG HOLLOW RD	MC 212	D356		1500 A	1600 A	1600 E
211	TH1 MAIN RD	7	HUNTINGTON	6.580	HINESBURG HOLLOW RD	MC 212	7.400	BRIDGE ST/EAST ST	TH-3/TH-4					2000 E
211	TH1 MAIN RD	7	HUNTINGTON	7.400	BRIDGE ST	TH-3/TH-4	9.700	RICHMOND TL		D359/DYAF		2400 E	2500 E	2200 A
211	TH1 HUNTINGTON RD	7	RICHMOND	0.000	HUNTINGTON TL		3.470	HINESBURG RD	MC 209	D346/349/YAI		2400 A	2500 A	2500 E
212	TH5 HINESBURG HOLLOW RD	7	HINESBURG	0.000	VT 116	VT 116	2.800	STARKSBORO TL		D360	ATR	1600 A	1600 A	1600 E
212	TH2 HINESBURG HOLLOW RD	7	STARKSBORO	0.000	HINESBURG TL		0.170	BIG HOLLOW RD	TH-5			1600 E	1600 E	1600 E
212	TH2 HINESBURG HOLLOW RD	7	STARKSBORO	0.170	BIG HOLLOW RD	TH-5	0.860	HUNTINGTON TL				1200 E	1200 E	1200 E
212	TH2 LINCOLN HILL RD	7	HUNTINGTON	0.000	STARKSBORO TL		1.480	MAIN RD	MC 211	D357	ATR	1200 A	1200 A	1200 E
213	TH10 GOVERNOR PECK RD	7	RICHMOND	0.000	VT 117	VT 117	0.800	JERICHO TL		D432/D714		2500 A	2300 A	2300 E
213	TH38 GOVERNOR PECK RD	7	JERICHO	0.000	RICHMOND TL		1.040	TARBOX RD	TH 35	DYAH/DYAG		2500 E	2300 E	2300 E
213	TH35 GOVERNOR PECK RD	7	JERICHO	1.040	TARBOX RD	TH 35	1.490	BROWNS TRACE RD	MC 209			3300 E	3200 E	3200 E
214	TH7 BRIDGE ST/MORRISON RD	7	BARRE	0.000	VT 14	VT 14	1.450	PROSPECT ST	FAU 6117	W373	ATR	2500 E	2400 A	2400 E
215	TH2 RYEGATE-PEACHAM RD	7	GROTON	0.000	US 302	US 302	2.540	RYEGATE TL		C335		510 A	480 A	430 A
215	TH4 PEACHAM-GROTON RD	7	RYEGATE	0.000	GROTON TL		0.940	HALL RD	TH-6			510 E	480 E	430 E
215	TH4 PEACHAM-GROTON RD	7	RYEGATE	0.940	HALL RD	TH-6	2.090	ELIZABETH FARM RD	TH-9	C330		330 A	320 A	320 E
215	TH4 PEACHAM-GROTON RD	7	RYEGATE	2.090	ELIZABETH FARM RD	TH-9	2.320	BARNET TL			ATR	110 E	250 E	250 E
215	TH4 GROTON RD	7	BARNET	0.000	RYEGATE TL		1.360	FARROW FARM RD	TH-82		ATR	110 E	250 E	250 E
215	TH4 GROTON RD	7	BARNET	1.360	FARROW FARM RD	TH-82	1.800	PEACHAM TL		C186	ATR	330 A	310 A	310 E
215	TH3 GROTON RD	7	PEACHAM	0.000	BARNET TL		1.130	PEACHAM BARNET RD/GOV MATTOCKS	MC 216/TH-53	C704		340 A	270 E	270 E
215	TH1 GROTON RD	7	PEACHAM	1.130	BARNET RD (S 0216)	TH-1/TH-35	4.231	EWELL MILL RD	TH-16	C337/340/ZDN		550 A	580 A	580 E
215	TH1 DANVILLE RD	7	PEACHAM	4.420	EWELL MILL RD	TH-16	5.690	DANVILLE TL		CYAD		830 A	920 E	840 E
215	TH3 E PEACHAM RD	7	DANVILLE	0.000	PEACHAM TL		2.800	TH 121/TH 120	TH-121/TH-120	C342		830 E	1100 A	1100 E
215	TH3 E PEACHAM RD	7	DANVILLE	2.800	FIELD RD/	TH-121/TH-120	3.260	US 2	US 2		ATR	2100 E	2100 E	1600 E
215	TH2 N DANVILLE RD	7	DANVILLE	3.260	US 2	US 2	3.880	WEBSTER HILL RD	TH-35	C242		1100 E	1100 E	1100 A
215	TH2 N DANVILLE RD	7	DANVILLE	3.880	WEBSTER HILL RD	TH-35	6.800	MCDOWELL RD	Minor 752	C343		650 A	550 A	540 A
215	TH2 N DANVILLE RD	7	DANVILLE	6.800	MCDOWELL RD	Minor 752	10.220	ST. JOHNSBURY TL		C244			500 A	460 A
216	TH1 BARNET RD	7	PEACHAM	0.000	GROTON RD (S 0215)	MC 215	0.900	BARNET TL	BARNET TL	C336	ATR	590 A	770 E	560 A
216	TH1 PEACHAM RD	7	BARNET	0.000	PEACHAM TL	PEACHAM TL	0.500	HARVEY MTN RD	TH-10	CZAR		590 E	770 E	850 E
216	TH1 MAIN ST	7	BARNET	0.500	HARVEY MTN RD	TH-10	2.340	E.PEACHAM RD	TH-2	C328		860 A	970 E	890 A
216	TH1 W BARNET RD	7	BARNET	2.340	E.PEACHAM RD	TH-2	5.040	BARNET STATE HWY.	BSH	C327/CZDF		1600 A	1700 E	1600 E
											ATR			
218	TH4 OREGON RD	7	CONCORD	0.000	US 2	US 2	2.910	W THOMAS RD/CEDAR ST	TH-9/TH-10	E308/EZAE		550 A	460 E	380 E
218	TH4 OREGON RD	7	CONCORD	2.910	W THOMAS RD/CEDAR ST	TH-9/TH-10	3.560	LUNENBURG TL		E308		520 E	360 A	360 E
218	TH1 E CONCORD RD	7	LUNENBURG	0.000	CONCORD TL		1.520	TOWN HIGHWAY 3	TH-3	E307	ATR	520 A	430 A	430 E
218	TH1 E CONCORD RD	7	LUNENBURG	1.520	TOWN HIGHWAY 3	TH-3	4.830	LUNENBURG RD	MC 219	E306/CZD		620 A	650 A	650 E

VERMONT AGENCY OF TRANSPORTATION
HIGHWAY DIVISION
Traffic Research Unit

NO.	NAME	FC	TOWN	BEGINNING REFERENCE: MM	NAME	NUMBER	ENDING REFERENCE: MM	NAME	NUMBER	ATR STA	TYPE	2007 AADT	2011 AADT	2014 AADT
218	TH1 E CONCORD RD	7	LUNENBURG	4.830	LUNENBURG RD	TH-2(S 0219)	6.840	MT. ORNE BRIDGE RD	TH-4	E304		370 A	400 A	400 E
218	TH1 E CONCORD RD	7	LUNENBURG	6.840	MT. ORNE BRIDGE RD	TH-4	7.250	US 2	US 2	EYAF		950 A	520 E	700 E
219	TH2 LUNENBURG RD	7	LUNENBURG	0.000	E.CONCORD RD	MC 218	1.900	US 2	US 2	E305		410 A	430 A	430 E
											ATR			
220	TH3 WATERFORD SPRINGS RD	7	BARNET	0.000	US 5	US 5	3.660	WATERFORD TL		C326/CZDG		120 A	180 A	180 E
220	TH2 WHITE VILLAGE RD	7	WATERFORD	0.000	BARNET TL		2.760	DUCK POND RD	TH-3	C325		190 A	150 A	110 A
220	TH2 WHITE VILLAGE RD	7	WATERFORD	2.760	DUCK POND RD	TH-3	5.190	VT 18	VT 18	C323/CZDQ		340 A	370 A	300 E
221	S ACCESS RD	7	DOVER	0.000	HANDLE RD	MC 115	0.230	VT 100	VT 100	X087	ATR	510 A	500 E	950 A
222	TANNERY RD	7	DOVER	0.000	HANDLE RD	MC 115	0.520	VT 100	VT 100	X358	ATR	780 A	1000 A	1000 E
223	TH3 BOLTON VALLEY RD	7	BOLTON	0.000	US 2	US 2	4.370	BOLTON VALLEY		D059		1100 A	950 A	890 A
224	TH6 BRIDGE ST.	7	ROCKINGHAM (BELLOWS FA	0.000	WESTON ST.	MC 117	0.249	NH STATE LINE		X267	ATR	3300 A	3200 E	3200 E
227	TH8 SCONNELL RD	7	BRANDON	0.000	US 7	US 7	3.300	VT 73	VT 73	R492		1500 A	1600 A	1600 E
											ATR			
230	TH2 N MAIN ST	7	HARTFORD (WRJ)	0.000	US 5	US 5	0.250	CURRIER ST/N MAIN ST	TH 163/TH 78	YXPI		4000 E	2400 E	3100 A
230	TH2 BRIDGE ST	7	HARTFORD (WRJ)	0.250	CURRIER ST/BRIDGE ST	TH 163/TH 78	0.310	BRIDGE ST	TH 2	Y746	ATR	5300 E	4100 E	3800 E
230	TH162 RAILROAD ROW	7	HARTFORD (WRJ)	0.310	BRIDGE ST	TH 2	0.411	END OF ST		YXPH		560 E	530 E	530 E
											ATR			
233	TH5 STEAM MILL RD	7	JERICHO	0.000	VT 15	VT 15	0.430	UNDERHILL TL		D388		3300 A	3200 E	3200 E
233	TH1 RIVER RD	7	UNDERHILL	0.000	JERICHO TL		2.290	KRUG RD	TH-42	D316		3300 E	3200 E	3200 E
233	TH1 RIVER RD	7	UNDERHILL	2.290	KRUG RD	TH-42	3.320	MOUNTAIN RD	TH-2	DYAM		2200 A	2200 E	2200 E
233	TH1 PLEASANT VALLEY RD	7	UNDERHILL	3.320	MOUNTAIN RD	TH-2	8.340	CAMBRIDGE TL		D314	ATR	1100 A	970 A	970 E
233	TH1 LOWER VALLEY RD	7	CAMBRIDGE	0.000	UNDERHILL TL		0.543	LOWER PLEASANT VALLEY RD	Minor 744	L701	ATR	790 E	970 E	970 E
233	TH5 UPPER VALLEY RD	7	CAMBRIDGE	0.543	LOWER PLEASANT VALLEY RD	TH-1	4.280	WILLIAMSON RD	TH-28	L319		980 A	960 E	960 E
233	TH5 UPPER VALLEY RD	7	CAMBRIDGE	4.280	WILLIAMSON RD	TH-28	4.800	CHURCH ST	VT 108 APP	L151	ATR	1800 A	1800 E	1800 E
											ATR			
236	TH1 MOSCOW RD	7	STOWE	0.000	VT 100	VT 100	1.520	MOSCOW RD	TH-1	L322/L715		3100 A	3000 E	3800 A
236	TH5 BARROWS RD	7	STOWE	1.520	MOSCOW RD	TH 1	3.320	LUCE HILL RD	TH-41	L011/713/714	ATR	2900 E	2300 A	2300 E
236	TH5 LUCE HILL RD	7	STOWE	3.320	BARROWS RD	TH-41	3.870	MOUNTAIN RD	VT 108	L012		3600 E	4300 E	4300 E
											ATR			
237	TH4 STAGECOACH RD	7	STOWE	0.000	VT 100	VT 100	1.560	MORRISTOWN TL		L004	ATR	1900 A	2100 A	2100 E
237	TH5 STAGECOACH RD	7	MORRISTOWN	0.000	STOWE TL		5.600	CADY FALLS RD	MC 239	L003		1700 A	1900 E	2600 A
238	TH5 BRIDGE ST	7	MORRISTOWN	0.000	CADY FALLS RD	MC 239	0.603	ALT TRUCK RTE	VT 100	L313/170		1800 A	1900 A	1900 E
238	TH5 BRIDGE ST	7	MORRISVILLE	0.730	ALT TRUCK RTE	VT 100	0.730	VT 100	VT 100			2300 A	2300 E	2300 E
239	TH2 CADY FALLS RD	7	MORRISTOWN	0.000	VT 100	VT 100	0.050	MILLER BRIDGE RD	TH-34		ATR	1000 E	1000 E	1000 E
239	TH2 CADY FALLS RD	7	MORRISTOWN	0.050	MILLER BRIDGE RD	TH-34	1.000	BRIDGE ST	MC 238	L312		2700 A	2700 A	2700 A
239	TH2 CADY FALLS RD	7	MORRISTOWN	1.000	BRIDGE ST	TH-3	1.400	STAGE COACH RD	MC 237		ATR	1900 E	1900 E	2000 E
239	TH2 CADY FALLS RD	7	MORRISTOWN	1.400	STAGE COACH RD	TH-5	1.730	GRIGGS RD/LACLAIR RD	TH-9/TH-11	L314	ATR	3100 A	2900 E	3300 A

VERMONT AGENCY OF TRANSPORTATION
HIGHWAY DIVISION/TSMO
Traffic Research Unit

					BEGINNING REFERENCE:			ENDING REFERENCE:					2010	2012	2015
TYPE	NO.	NAME	FC	TOWN	MM	NAME	NUMBER	MM	NAME	NUMBER	ATR STA	STATUS	AADT	AADT	AADT
US	2		2	CONCORD	10.661	OREGON RD	TH-4	10.765	LUNENBURG TL				2000 E	2300 E	2200 E
US	2		2	LUNENBURG	0.000	CONCORD TL		3.943	BAPTIST HILL RD	TH 5	E102		2000 E	2300 E	2100 E
US	2		2	LUNENBURG	3.943	BAPTIST HILL RD	TH 5	4.681	LUNENBURG RD	TH-2			3200 E	3000 E	2400 E
US	2		2	LUNENBURG	4.681	LUNENBURG RD	TH-2	6.227	RIVER RD	TH-1	E103		3100 E	2800 E	1900 E
US	2		2	LUNENBURG	6.227	RIVER RD	TH-1	6.927	BOBBIN MILL RD	TH-34			3400 E	3100 E	2300 E
US	2		2	LUNENBURG	6.927	BOBBIN MILL RD	TH-34	9.039	GUILDHALL TL		E104		3300 E	2600 E	3000 E
US	2		2	GUILDHALL	0.000	LUNENBURG TL		1.047	VT 102		E008		3300 A	2600 A	3000 A
US	2		2	GUILDHALL	1.047	VT 102		1.149	NEW HAMPSHIRE SL		E131		3400 A	3200 A	3200 A
BUSINESS ROUTE US 2															
BR US	2	STATE ST	16	MONTPELIER	0.000	US 2 (BAILEY AVE)	(TH-12)	0.277	TAYLOR ST/GOV DAVIS AVE	TH-9/	W185/028		8100 E	7300 A	7300 E
BR US	2	STATE ST	16	MONTPELIER	0.277	TAYLOR ST/GOV DAVIS AVE	TH-9/	0.384	ELM ST	TH-15			7800 E	7100 E	8600 E
BR US	2	STATE ST	16	MONTPELIER	0.384	ELM ST	TH-15	0.483	VT 12 (MAIN ST)	(TH-5)	W187		7000 E	6300 E	5700 E
BR US	2	MAIN ST	16	MONTPELIER	0.483	VT 12 (MAIN ST)	(TH-5)	0.600	BARRE ST	TH-10			12100 E	10900 E	12000 E
BR US	2	MAIN ST	16	MONTPELIER	0.600	BARRE ST	TH-10	0.687	US 2 (MEMORIAL DR/BERLIN ST)	(TH-1)			11000 E	9900 E	10400 E
US ROUTE 4															
US	4		2	FAIR HAVEN	0.000	NEW YORK SL		0.150	VT 4A		R020	C	7900 E	7500 E	7700 E
US	4		2	FAIR HAVEN	0.150	VT 4A		1.676	VT 22A	EXIT 2	R001	W	7300 A	6800 A	7100 E
US	4		2	FAIR HAVEN	1.676	VT 22A	EXIT 2	2.573	FAIR HAVEN SH	EXIT 3	R002		6700 A	6800 E	6600 E
US	4		2	FAIR HAVEN	2.573	FAIR HAVEN SH	EXIT 3	3.491	CASTLETON TL				8400 E	8500 E	8700 E
US	4		2	CASTLETON	3.491	FAIR HAVEN TL		5.449	VT 30	EXIT 4	R003		8400 A	8500 E	8700 E
US	4		2	CASTLETON	5.449	VT 30	EXIT 4	7.758	CASTLETON SH	EXIT 5	R004		11700 A	11800 E	12300 E
US	4		2	CASTLETON	7.758	CASTLETON STATE HIGHWAY	EXIT 5	10.529	IRA TL				13300 E	13100 E	13100 E
US	4		2	IRA	10.529	CASTLETON TL		11.697	W RUTLAND TL				13300 E	13100 E	13100 E
US	4		2	W RUTLAND	11.697	IRA TL		14.899	BR US 4	EXIT 6	R084	C	13300 A	13100 A	13100 A
US	4		2	W RUTLAND	14.899	BR US 4	EXIT 6	16.384	RUTLAND TL				10000 E	10600 E	7600 E
US	4		2	RUTLAND TOWN	16.384	W RUTLAND TL		18.829	US 7 (US-4 PICKS UP AGAIN IN CITY)		R485		10000 E	10600 E	7600 E
US	4	WOODSTOCK AVE	14	RUTLAND CITY	0.000	US 7		0.954	STRATTON RD.	TH-9	R201		12400 A	12400 E	14300 E
US	4	WOODSTOCK AVE	14	RUTLAND CITY	0.954	STRATTON RD	TH-9	1.250	RUTLAND CL/TL/GLEASON RD		R228		12100 E	16400 E	15000 E
US	4		14	RUTLAND TOWN	0.000	RUTLAND CL/GLEASON RD		0.173	SHOPPING CTR		R077		14400 A	14200 A	14600 A
US	4		14	RUTLAND TOWN	0.173	SHOPPING CTR		1.234	MENDON TL/TOWN LINE RD	TH-2	R081		10800 A	10800 E	12500 A
US	4		14	MENDON	0.000	RUTLAND TL/TOWN LINE RD	/TH-2	0.877	PARK LANE	TH-3	R111		11300 E	11300 E	13000 E
US	4		2	MENDON	0.877	PARK LANE	TH-3	1.254	MEADOW LAKE DR	TH-1			12000 E	10200 E	11100 E
US	4		2	MENDON	1.254	MEADOW LAKE DR	TH-1	3.417	CREAM HILL RD	TH-4	R112		9300 E	9300 E	10400 E
US	4		2	MENDON	3.417	CREAM HILL RD	TH-4	5.928	KILLINGTON TL		R082		9000 A	8800 E	7700 A
US	4		2	KILLINGTON	0.000	MENDON TL		0.212	NORTHSIDE RD	TH-120			9000 E	8800 E	7700 E
US	4		2	KILLINGTON	0.212	NORTHSIDE RD	TH-120	2.115	VT 100N		R005	C	9200 A	8700 A	9200 A
US	4		2	KILLINGTON	2.115	VT 100N		2.352	KILLINGTON RD	TH-2			7400 E	6700 E	7100 E
US	4		2	KILLINGTON	2.352	KILLINGTON RD	TH-2	3.487	WEST HILL RD	TH-3	R113		4600 E	4500 E	5300 E
US	4		2	KILLINGTON	3.487	WEST HILL RD	TH-3	4.212	RIVER RD	TH-1			5200 E	5100 E	5000 E
US	4		2	KILLINGTON	4.212	RIVER RD	TH-1	8.495	BRIDGEWATER TL		R114		5400 A	5500 E	4900 A
US	4		2	BRIDGEWATER	0.000	KILLINGTON TL		0.057	VT 100S				4800 E	4400 E	4800 E
US	4		2	BRIDGEWATER	0.057	VT 100S		5.456	BRIDGEWATER CENTER RD	TH-1	Y113/117	W	4100 E	3700 A	4200 A

TYPE	NO.	NAME	FC	TOWN	BEGINNING REFERENCE: MM	NAME	NUMBER	ENDING REFERENCE: MM	NAME	NUMBER	ATR STA	STATUS	2010 AADT	2012 AADT	2015 AADT
VT ROUTE 101															
VT	101		07	TROY	0.000	VT 100		3.132	VT 242		P134		1900 A	1900 E	1700 A
VT	101		07	TROY	3.132	VT 242		4.333	VT 105		P224		1400 E	1400 E	1200 E
VT ROUTE 102															
VT	102		07	GUILDHALL	0.000	US 2		5.021	GRANBY RD/PENDRIGH RD	TH-1/TH-6	E105		640 E	580 A	600 E
VT	102		07	GUILDHALL	5.021	GRANBY RD/PENDRIGH RD	TH-1/TH-6	7.221	BRIDGE ST	TH-2	E106		920 E	840 E	640 E
VT	102		07	GUILDHALL	7.221	BRIDGE ST	TH-2	7.748	MAIDSTONE TL				500 E	510 E	440 E
VT	102		07	MAIDSTONE	0.000	GUILDHALL TL		7.823	BRUNSWICK TL		E107		500 A	510 E	440 A
VT	102		07	BRUNSWICK	0.000	MAIDSTONE TL		7.080	BLOOMFIELD TL		E034/700/703		540 A	550 E	460 E
VT	102		07	BLOOMFIELD	0.000	BRUNSWICK TL		0.351	VT 105				330 E	550 E	460 E
VT	102		07	BLOOMFIELD	0.351	VT 105		6.950	LEMINGTON TL		E109/110/702		360 A	360 E	350 E
VT	102		07	LEMINGTON	0.000	BLOOMFIELD TL		2.135		TH-3			360 E	360 E	350 E
VT	102		07	LEMINGTON	2.135		TH-3	6.297	VT 26		E111		270 A	270 E	290 A
VT	102		07	LEMINGTON	6.297	VT 26		7.324	CANAAN TL		E701		650 E	570 A	590 E
VT	102		07	CANAAN	0.000	LEMINGTON TL		1.388	TODD HILL RD	TH-20	E112		430 A	440 E	350 A
VT	102		07	CANAAN	1.388	TODD HILL RD	TH-20	5.765	CANAAN HILL RD	TH-15			760 E	780 E	800 E
VT	102		07	CANAAN	5.765	CANAAN HILL RD	TH-15	6.830	VT 114/VT 253		EXBA		680 E	700 E	890 E
VT ROUTE 103															
VT	103		07	ROCKINGHAM	0.000	US 5		0.035	I 91 RAMP B: EXIT 6				6700 E	5600 E	4700 E
VT	103		07	ROCKINGHAM	0.035	I 91 RAMP B: EXIT 6		0.142	I 91 RAMP F: EXIT 6				5500 E	4900 E	4800 E
VT	103		02	ROCKINGHAM	0.142	I 91 RAMP F: EXIT 6		0.255	I 91 RAMPS C/G/H: EXIT 6				6000 E	5500 E	6300 E
VT	103		02	ROCKINGHAM	0.255	I 91 RAMPS C/G/H: EXIT 6		1.224	SCHOOLHOUSE DEPOT RD	TH-75			6300 A	6400 A	6900 A
VT	103		02	ROCKINGHAM	1.224	SCHOOLHOUSE RD	TH-75	1.359	OLD VT 103	TH-78	X111		6500 E	6700 E	7000 E
VT	103		02	ROCKINGHAM	1.359	OLD VT 103	TH-78	3.292	PLEASANT VALLEY RD	TH-2	X249	W	6000 A	6100 A	6100 A
VT	103		02	ROCKINGHAM	3.292	PLEASANT VALLEY RD	TH-2	3.487	BREAKWAY MILLS	TH-4			6300 E	5700 E	6200 E
VT	103		02	ROCKINGHAM	3.487	BREAKWAY MILLS	TH-4	5.373	BARTONVILLE RD	TH-8	X110		5000 E	5100 E	5300 E
VT	103		02	ROCKINGHAM	5.373	BARTONVILLE RD	TH-8	6.753	CHESTER TL				4500 E	4700 E	5700 E
VT	103		02	CHESTER	0.000	ROCKINGHAM TL		0.565	PECK RD	TH-6	Y427		4500 E	4700 E	5700 E
VT	103		02	CHESTER	0.565	PECK RD	TH-6	2.489	VT 11		Y162/192		6800 A	6900 E	7400 E
VT	103	S MAIN ST	02	CHESTER	2.489	VT 11		2.876	MAPLE ST	TH-4	Y194		8600 A	8700 E	8900 E
VT	103	MAPLE ST	02	CHESTER	2.968	MAPLE ST	TH4	3.006	DEPOT ST	TH-1	Y195		2900 E	2900 E	3500 E
VT	103	DEPOT ST	02	CHESTER	3.006	DEPOT ST	TH-1	3.621	FLAMSTEAD RD/FIRST AVE	TH-9/TH-87	Y061/Y200		4200 A	4200 A	4200 A
VT	103	DEPOT ST	02	CHESTER	3.621	FLAMSTEAD RD/FIRST AVE	TH-9/TH-87	3.738	GREEN MTN TURNPIKE	TH-6			3600 E	3600 E	4100 E
VT	103	NORTH ST	02	CHESTER	3.738	GREEN MTN TURNPIKE	TH-6	4.270	CHURCH ST	TH-5	Y202/386		3900 E	3800 E	4400 E
VT	103		02	CHESTER	4.270	CHURCH ST	TH-5	7.641	VT 10		Y161		4000 A	3800 E	5200 E
VT	103		02	CHESTER	7.641	VT 10		8.717	CAVENDISH RD	TH-19			5100 E	5900 E	6400 E
VT	103		02	CHESTER	8.717	CAVENDISH RD	TH-19	9.730	CAVENDISH TL				5100 E	5200 E	6100 E
VT	103		02	CAVENDISH	0.000	CHESTER TL		2.043	DEPOT ST	TH-1	Y160		5100 A	5200 E	6100 E
VT	103		02	CAVENDISH	2.043	DEPOT ST	TH-1	2.824	VT 131		Y712		4700 A	4800 E	4600 A
VT	103		02	CAVENDISH	2.824	VT 131		3.741	LUDLOW TL		Y159		7600 A	8000 A	8000 A
VT	103		02	LUDLOW	0.000	CAVENDISH TL		0.306	EAST HILL RD	TH-29			8500 E	8000 E	8700 E

Croydon
0560

146/124 NH 10 over CROYDON BRANCH SUGAR R — May 2014 91.1 NHDOT — IB-C 35.6 38 1 Fed Br NPR Y 1935, 1993
Not Deficient *Over* — *3500, 2012 18 mi 31.8 Rural Mjr. Collector* *Primary-DOT Maintained*
Deck: 7 Good **Superstructure:** 7 Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

155/054 MILL ROAD over OUTLET LONG POND — May 2014 * 80.1 NHDOT — MP .0 13 1 NPR Y 1973
Not Applicable *Over* — *460, 2012 2 mi 28.0 Rural Local* *Secondary-DOT Maintained*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 6 Satisfactory **Scour Critical Rating:** Stable for extreme flood

Dalton
0570

082/121 NH135 over BROOK — Jun 2015 * 98.0 NHDOT — MP .0 10 1 NPR Y 1931
Not Applicable *Over* — *1300, 2013 20 mi 35.0 Rural Mjr. Collector* *Secondary-DOT Maintained*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 6 Satisfactory **Scour Critical Rating:** Stable for extreme flood

089/130 BRIDGE HILL ROAD over CONNECTICUT RIVER — Aug 2014 96.2 NHDOT — IB-C 39.5 591 3 Fed Br NPR Y 1997
Not Deficient *Over* — *1000, 2012 20 mi 31.5 Rural Mjr. Collector* *Secondary-DOT Maintained*
Deck: 7 Good **Superstructure:** 8 Very Good **Substructure:** 8 Very Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

090/130 BYPASSED HISTORIC over CONNECTICUT RIVER — Jun 2015 N/A NHDOT — DT 21.4 547 7 Fed Br BRC Y 1928
Whitcomb Bridge **Historic or Bypassed** Not Applicable *Over* — *0, 2002 20 mi 20.0 Rural Local* *Undetermined / NA*
Deck: 1 Closed - Faili **Superstructure:** 1 Closed - Faili **Substructure:** 1 Closed - Failing **Culvert:** N N/A (NBI) **Scour Critical Rating:** Closed - Failing

134/153 NH135 over JOHNS RIVER — Jun 2015 93.8 NHDOT — NEBT 32.8 85 1 Fed Br NPR Y 1997
Not Deficient *Over* — *920, 2012 3 mi 29.1 Rural Mjr. Collector* *Secondary-DOT Maintained*
Deck: 8 Very Good **Superstructure:** 8 Very Good **Substructure:** 8 Very Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

173/142 NH142 over BLACK BROOK — Jul 2014 83.0 NHDOT — CS 31.8 17 1 NPR Y 1934
Not Applicable *Over* — *550, 2012 2 mi 28.0 Rural Min. Collector* *Secondary-DOT Maintained*
Deck: 6 Satisfactory **Superstructure:** 6 Satisfactory **Substructure:** 5 Fair **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

178/129 FRENCH ROAD over JOHNS RIVER — Aug 2014 92.4 Municipality — IB-C 27.1 55 1 Fed Br NPR Y 1948, 2002
Not Deficient *Over* — *200, 2012 6 mi 24.1 Rural Local* *Municipal Highway*
Deck: 7 Good **Superstructure:** 7 Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

194/093 FARAWAY ROAD over JOHNS RIVER — Aug 2014 95.8 Municipality — IB-C 32.0 79 1 Fed Br E2 Y 1976
Not Deficient *Over* — *470, 2011 1 mi 28.0 Rural Local* *Municipal Highway*
Deck: 7 Good **Superstructure:** 8 Very Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

Danbury
0580

081/075 WILD MEADOW ROAD over WILD MEADOW BROOK — Jul 2014 55.7 Municipality — IB-C 20.0 25 1 Fed Br E2 Y 1950, 1979
Functionally Obsolete *Over* — *320, 1987 6 mi 19.3 Rural Local* *Municipal Highway*
Deck: 7 Good **Superstructure:** 7 Good **Substructure:** 6 Satisfactory **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

Bridge Data --> Insp Date FSR Owner Type Width Length Spans Weight VC over/under Year Built
Road Data --> AADT, Year Detour Width Functional Class NH System / Class & Rebuilt

Lancaster

1410

038/040 MARTIN MEADOW ROAD over BLACK BROOK Sep 2014 * 95.7 Municipality CRF-P .0 17 1 NPR Y 1993
Not Applicable *Over* *450 , 1987* *10 mi* *19.5* *Rural Local* *Municipal Highway*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 8 Very Good **Scour Critical Rating:** Stable for extreme flood

039/105 MT ORNE ROAD over CONNECTICUT RIVER Oct 2015 29.0 Municipality TB-C 15.3 266 2 Fed Br 06 Y 13.12 1911 , 1988
Mount Orne Covered Br. **Municipal Redlist** Structurally Deficient *Over* *590 , 2012* *14 mi* *14.4* *Rural Mjr. Collector* *Secondary-DOT Maintained*
Deck: 6 Satisfactory **Superstructure:** 7 Good **Substructure:** 6 Satisfactory **Culvert:** N N/A (NBI) **Scour Critical Rating:** Countermeasures in plac

111/129 US 2 over CONNECTICUT RIVER Nov 2015 32.5 NHDOT HT 34.8 404 2 Fed Br E1 Y 14.01 1950
Rogers Rangers Bridge **State Redlist** Structurally Deficient *Over* *NHS* *3800 , 2012* *9 mi* *28.0* *Rural Princ. Arterial* *Primary-DOT Maintained*
Deck: 4 Poor **Superstructure:** 4 Poor **Substructure:** 4 Poor **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

130/110 US 2,US 3 over ISRAEL RIVER Jun 2014 80.0 NHDOT IB-C 49.7 136 1 Fed Br NPR Y 1990
Not Deficient *Over* *NHS* *10000 , 2013* *28 mi* *32.0* *Rural Princ. Arterial* *Primary-DOT Maintained*
Deck: 8 Very Good **Superstructure:** 8 Very Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

134/107 MECHANIC STREET over ISRAEL RIVER Oct 2015 * 23.7 Municipality TB-C 20.0 94 1 Fed Br 03P Y 8.40 1862 , 2006
Israels Covered Bridge **Municipal Redlist** Structurally Deficient *Over* *710 , 2012* *1 mi* *18.0* *Rural Local* *Municipal Highway*
Deck: 8 Very Good **Superstructure:** 7 Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

135/121 DEPOT STREET over BROOK Aug 2015 * 97.0 Municipality CRF-P .0 12 1 NPR Y 2009
Not Deficient *Over* *500 , 2009* *0 mi* *28.7* *Rural Local* *Municipal Highway*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 8 Very Good **Scour Critical Rating:** Stable for extreme flood

140/120 NHRR over CEMETERY STREET Sep 2015 N/A NHDOT TPG 9.8 29 1 Fed Br NPR Y 8.32 1930
Not Applicable *Road Under* *100 , 1986* *0 mi* *20.7* *Rural Local* *Municipal Highway*
Deck: 8 Very Good **Superstructure:** 6 Satisfactory **Substructure:** 5 Fair **Culvert:** N N/A (NBI) **Scour Critical Rating:** Not Over Waterway

160/082 NORTH ROAD over OTTER BROOK May 2015 79.4 NHDOT IB-C 27.7 63 1 Fed Br NPR Y 1958
Not Deficient *Over* *1600 , 2012* *3 mi* *24.2* *Rural Min. Collector* *Secondary-DOT Maintained*
Deck: 7 Good **Superstructure:** 7 Good **Substructure:** 8 Very Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

173/090 GARLAND ROAD over OTTER BROOK Aug 2014 89.9 Municipality CS 26.5 28 1 Fed Br NPR Y 1992
Not Deficient *Over* *260 , 2012* *6 mi* *24.0* *Rural Local* *Municipal Highway*
Deck: 8 Very Good **Superstructure:** 8 Very Good **Substructure:** 8 Very Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

180/098 GRANGE ROAD over BURNSIDE BROOK Jun 2014 96.9 NHDOT IB-C 33.0 49 1 Fed Br NPR Y 1984
Not Deficient *Over* *400 , 1984* *4 mi* *30.0* *Rural Min. Collector* *Secondary-DOT Maintained*
Deck: 7 Good **Superstructure:** 8 Very Good **Substructure:** 8 Very Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

183/045 NORTH ROAD over GARLAND BROOK Jun 2014 86.9 NHDOT CRF 27.1 48 1 Fed Br NPR Y 1960
Not Deficient *Over* *580 , 2012* *3 mi* *24.1* *Rural Min. Collector* *Secondary-DOT Maintained*
Deck: 7 Good **Superstructure:** 7 Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

Bridge Data --> Insp Date FSR Owner | Type Width Length Spans | Weight VC over/under | Year Built
Road Data --> | *AADT, Year Detour Width Functional Class* | *NH System / Class* | & Rebuilt

Northumberland
1980

093/122 SL&ARR over NH110 — Jun 2015 N/A Railroad — CS 13.3 50 1 Fed Br NPR Y 14.19 1937
Not Applicable *Road Under* *1900 ,2012 0 mi 31.5 Rural Mjr. Collector Primary-DOT Maintained*
Deck: 5 Fair **Superstructure:** 5 Fair **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Not Over Waterway

104/120 NH110 over ROARING BROOK — Jun 2014 *99.1 NHDOT — CRF .0 34 1 Fed Br NPR Y 1962
Not Deficient *Over* *1900 ,2012 6 mi 32.8 Rural Minor Arterial Primary-DOT Maintained*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 7 Good **Scour Critical Rating:** Stable for extreme flood

106/112 US 3 over UPPER AMMONOOSUC RIVER — Aug 2014 87.9 NHDOT — IB-C 57.5 235 2 Fed Br NPR Y 1995
Not Deficient *Over* *5900 ,2010 25 mi 49.5 Rural Minor Arterial Primary-DOT Maintained*
Deck: 7 Good **Superstructure:** 8 Very Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable, Scour to footing

106/113 BYPASSED HISTORIC over UPPER AMMONOOSUC RIVER — Aug 2015 N/A Municipality — TB-C 18.0 132 1 Fed Br BRC Y 10.50 1852
Groveton Covered Bridge **Historic or Bypassed** Not Applicable *Over* *0 ,1993 99 mi 3.5 Rural Local Unmaintained Highway*
Deck: 1 Closed - Faili **Superstructure:** 1 Closed - Faili **Substructure:** 1 Closed - Failing **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

107/122 WINTER STREET over ROARING BROOK — Dec 2015 49.9 NHDOT — CRF 24.6 28 1 Fed Br NPR Y 1956
State Redlist Structurally Deficient *Over* *380 ,2012 1 mi 21.0 Rural Min. Collector Secondary-DOT Maintained*
Deck: 4 Poor **Superstructure:** 4 Poor **Substructure:** 6 Satisfactory **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

108/114 BROOKLYN STREET over ROARING BROOK — Aug 2015 N/A Municipality — MP .0 15 2 BRC Y 1991
Closed Bridge Not Applicable *Over* *0 ,1987 0 mi 21.0 Rural Local Municipal Highway*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 1 Closed - Faili **Scour Critical Rating:** Stable for extreme flood

141/059 GUILDHALL ROAD over CONNECTICUT RIVER — Aug 2014 90.1 NHDOT — IB-C 37.5 314 3 Fed Br NPR Y 1984
Not Deficient *Over* *820 ,2013 14 mi 29.3 Rural Minor Arterial Secondary-Municip Maint.*
Deck: 6 Satisfactory **Superstructure:** 7 Good **Substructure:** 6 Satisfactory **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

142/068 US 3 over DEAN BROOK — Jun 2014 *99.6 NHDOT — CACUL .0 12 1 NPR Y 1946
Not Applicable *Over* *4900 ,2012 1 mi 34.0 Rural Minor Arterial Primary-DOT Maintained*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 7 Good **Scour Critical Rating:** Stable for extreme flood

223/118 LOST NATION ROAD over FOX BROOK — Jun 2014 85.4 NHDOT — CS 27.5 16 1 NPR Y 1925 , 1954
Not Applicable *Over* *330 ,2013 8 mi 24.0 Rural Min. Collector Secondary-DOT Maintained*
Deck: 7 Good **Superstructure:** 7 Good **Substructure:** 7 Good **Culvert:** N N/A (NBI) **Scour Critical Rating:** Stable for extreme flood

Northwood
2000

043/096 US 4,US202,NH 9 over NARROWS BROOK — Apr 2014 *99.9 NHDOT — CRF .0 10 1 NPR Y 1934 , 1974
Not Applicable *Over* *NHS* *1100 ,2012 1 mi 44.0 Rural Princ. Arterial Primary-DOT Maintained*
Deck: N N/A (NBI) **Superstructure:** N N/A (NBI) **Substructure:** N N/A (NBI) **Culvert:** 7 Good **Scour Critical Rating:** Stable for extreme flood

Appendix C

BCA Resource Guide 2016

BENEFIT-COST ANALYSIS (BCA) RESOURCE GUIDE

How to Use This Guide

This BCA Resource Guide is a supplement to the *2016 Benefit-Cost Analysis Guidance for Grant Applicants* also found on this site (http://www.dot.gov/tiger/guidance) and on (https://www.transportation.gov/FASTLANEgrants). It provides technical information that Applicants will need for monetizing benefits and costs in their Benefit-Cost Analyses, as well as guidance on methodology and a selection of frequently asked questions from past TIGER grant applicants.
This guide is divided into three sections:

I. **Recommended Monetized Values**
For the purposes of providing as fair an "apples-to-apples" comparison as possible, applicants should use standard monetization values recommended in this section, which represent some of the values that are accepted for common practice at the U.S. Department of Transportation.

II. **Technical Methodologies**
This section provides guidance on the technical details of monetizing carbon dioxide (CO_2) emissions costs according to the Social Cost of Carbon standard developed by Federal agencies, converting nominal dollars into real dollars, and calculating the value of fatalities and injuries from vehicular crashes.

III. **Frequently Asked Questions (FAQs)**
This section provides answers to frequently asked questions from past TIGER applicants, with topics ranging from the logistical to the technical.

Updates to this document will be dated accordingly (with the nature of the updates noted on this cover page) and posted to the TIGER Discretionary Grants website (http://www.dot.gov/tiger) and to the NSFHP website (https://www.transportation.gov/FASTLANEgrants).

Updated 3/1/16

I. Recommended Monetized Values

Each project generates unique impacts in its respective community, and the grant Evaluation process respects these differences, particularly within the context of benefit-cost analysis. While the impacts may differ from place to place, the Department does recognize certain monetized values (and monetizing methodologies) as standard, such that various projects from across the country may be evaluated on a more equivalent "apples-to-apples" basis of comparison. The following table summarizes key values for various types of benefits and costs that the Department recommends that applicants use in their benefit-cost analyses. However, benefits and costs for any reliable analysis are not limited only to this table. The applicant should provide documentation of sources and detailed calculations for monetized values of additional categories of benefits and costs. Similarly, applicants using different values for the benefit/cost categories presented below should provide sources, calculations, and rationale for divergence from recommended values.

Table 1. Recommended Monetized Values

Cost/Benefit Category	Recommended Monetized Value(s)	Reference and Notes
Value of Statistical Life (VSL)	$9,600,000 per fatality ($2015)	*Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2016)* http://www.dot.gov/office-policy/transportation-policy/guidance-treatment-economic-value-statistical-life

Cost/Benefit Category	Recommended Monetized Value(s)	Reference and Notes
Value of Injuries	<table><tr><th>AIS Level</th><th>Severity</th><th>Fraction of VSL</th><th>Unit value ($2015)</th></tr><tr><td>AIS 1</td><td>Minor</td><td>0.003</td><td>$ 28,800</td></tr><tr><td>AIS 2</td><td>Moderate</td><td>0.047</td><td>$ 451,200</td></tr><tr><td>AIS 3</td><td>Serious</td><td>0.105</td><td>$ 1,008,000</td></tr><tr><td>AIS 4</td><td>Severe</td><td>0.266</td><td>$ 2,553,600</td></tr><tr><td>AIS 5</td><td>Critical</td><td>0.593</td><td>$ 5,692,800</td></tr><tr><td>AIS 6</td><td>Not survivable</td><td>1.000</td><td>$ 9,600,000</td></tr></table>	*Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2016)* http://www.dot.gov/office-policy/transportation-policy/guidance-treatment-economic-value-statistical-life **NOTE:** Accident data (particularly those provided through law enforcement records) are typically reported as a single number (e.g. "X number of crashes in Year Y") and/or on the KABCO scale of crash severity. Applicants should convert these values to the AIS scale before applying the recommended monetized values. See **Part II Section 3** (**"Converting Available Accident Data into AIS Data")**.

Cost/Benefit Category	Recommended Monetized Value(s)	Reference and Notes
Property Damage Only (PDO) Crashes	$4,198 per vehicle ($2015)	*The Economic and Societal Impact of Motor Vehicle Crashes, 2010* **NOTE:** Basis is PDO value of $3,862 ($2010) per vehicle involved in a PDO crash is an updated value currently used by NHTSA and based on the methodology and original 2000 dollar value referenced in *The Economic and Societal Impact of Motor Vehicle Crashes, 2010* (revised May 2015), Page 12, Table 1-2, Summary of Unit Costs, 2000". Also, while the cost of PDO crashes is presented here in 2010 dollars, applicants should convert this value (along with other monetized values presented in this section) to dollars applicable to whatever base year you are using, using the methodology discussed below in **Part II, Section 2 ("Converting Nominal Dollars into Real (Constant) Dollars").** The Resource Guide converted this value into 2015 dollars.

<table>
<tr><th>Cost/Benefit Category</th><th>Recommended Monetized Value(s)</th><th>Reference and Notes</th></tr>
<tr><td>Value of Travel Time</td><td>
<table>
<tr><th colspan="3">Recommended Hourly Values of Travel Time Savings
(2014 U.S. $ per person-hour)</th></tr>
<tr><th>Category</th><th>Surface Modes*
(except High-Speed Rail)</th><th>Air and
High-Speed Rail Travel</th></tr>
<tr><td>Local Travel</td><td></td><td></td></tr>
<tr><td>Personal</td><td>$12.90</td><td></td></tr>
<tr><td>Business</td><td>$24.90</td><td></td></tr>
<tr><td>All Purposes **</td><td>$13.45</td><td></td></tr>
<tr><td>Intercity Travel</td><td></td><td></td></tr>
<tr><td>Personal</td><td>$18.06</td><td>$34.31</td></tr>
<tr><td>Business</td><td>$24.90</td><td>$61.91</td></tr>
<tr><td>All Purposes **</td><td>$19.52</td><td>$45.46</td></tr>
<tr><td>Truck Drivers</td><td>$26.68</td><td></td></tr>
<tr><td>Bus Drivers</td><td>$27.60</td><td></td></tr>
<tr><td>Transit Rail Operators</td><td>$45.76</td><td></td></tr>
<tr><td>Locomotive Engineers</td><td>$40.13</td><td></td></tr>
<tr><td>Airline Pilots and Engineers</td><td>$87.00</td><td></td></tr>
<tr><td colspan="3">* Surface figures apply to all combinations of in-vehicle and other transit time. Walk access, waiting, and transfer time in personal travel should be valued at $25.80 per hour for personal travel when actions affect only those elements of travel time.

** These are weighted averages, using distributions of travel by trip purpose on various modes. Distribution for local travel by surface modes: 95.4% personal, 4.6% business. Distribution for intercity travel by conventional surface modes: 78.6% personal, 21.4% business. Distribution for intercity travel by air or high-speed rail: 59.6% personal, 40.4% business. Surface figures derived using annual person-miles of travel (PMT) data from the 2001 National Household Travel Survey. http://nhts.ornl.gov/. Air figures use person-trip data.</td></tr>
</table>
</td><td>Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis (Revision 2 – corrected)
http://www.dot.gov/office-policy/transportation-policy/guidance-value-time</td></tr>
</table>

Cost/Benefit Category	Recommended Monetized Value(s)	Reference and Notes
Value of Emissions	<table><tr><th>Emission Type</th><th>$ / short ton ($2015)</th><th>$ / metric ton ($2015)</th></tr><tr><td>Carbon dioxide (CO_2)</td><td>(varies)*</td><td>(varies)*</td></tr><tr><td>Volatile Organic Compounds (VOCs)</td><td>$1,844</td><td>$2,032</td></tr><tr><td>Nitrogen oxides (NOx)</td><td>$7,266</td><td>$8,010</td></tr><tr><td>Particulate matter (PM)</td><td>$332,405</td><td>$366,414</td></tr><tr><td>Sulfur dioxide (SOx)</td><td>$42,947</td><td>$47,341</td></tr></table> * See **"Social Cost of Carbon (3%)"** values below.	*Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks* (August 2012), page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 dollars)" http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/FRIA_2017-2025.pdf The Resource Guide converts these values into 2015 dollars. **NOTE:** Emissions units are frequently reported as "tons" throughout documents such as the CAFE rulemaking referenced above. However, it is important to distinguish between short tons and metric tons. Carbon dioxide emissions (as reported in the SCC guidance and elsewhere) are typically reported in metric tons, whereas emissions for VOCs, NOx, PMs, and SOx are measured in short tons. A short ton is 2,000 lbs., while a metric ton is approximately 2,205 lbs.

Cost/Benefit Category	Recommended Monetized Value(s)	Reference and Notes
Social Cost of Carbon (3%)	see tables below	*Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (May 2013; revised July 2015), page 17, Table A1 “Annual SCC Values: 2010-2050 (2007$/metric ton CO_2);” values for 3% discount rate. https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf **NOTE:** SCC values are reported per metric ton of carbon dioxide, and are already discounted to the reference years reported in the table. Unlike some previous OMB guidance on SCC values, the latest OMB guidance reports SCC values to the nearest dollar. The Resource Guide converted these to 2015 dollars and also reports the resulting values to the nearest dollar. - See **Part II, Section 1 (“Clarification on the Social Cost of Carbon (SCC) Guidance and the Annual SCC Values”)**, for methodology of how to use 3% SCC values in TIGER BCA.

Year	3% SCC (2015$)
2010	$35
2011	$36
2012	$37
2013	$38
2014	$39
2015	$41
2016	$43
2017	$44
2018	$45
2019	$46
2020	$47
2021	$47
2022	$48
2023	$50
2024	$51
2025	$52
2026	$53
2027	$54
2028	$55
2029	$55
2030	$56

Year	3% SCC (2015$)
2031	$58
2032	$59
2033	$60
2034	$61
2035	$62
2036	$63
2037	$64
2038	$65
2039	$67
2040	$68
2041	$69
2042	$69
2043	$70
2044	$71
2045	$72
2046	$73
2047	$74
2048	$76
2049	$77
2050	$78

II. Technical Methodologies

1. Clarification on the *Social Cost of Carbon* (SCC) Guidance and the Annual SCC Values

As noted in the recommended emissions values from Section I, there is no longer a fixed unit cost to carbon dioxide (CO_2) emissions. The Federal interagency Social Cost of Carbon (SCC) guidance states that the value of carbon dioxide emissions changes over time and should be discounted at the lower discount rates of 2.5%, 3%, or 5%.

However, the lack of 7% SCC values does not mean that applicants should ignore 7% discounting for the BCA. The document and its findings imply that carbon emissions are valued differently from other benefits and costs from the perspective of discount rate. Applicants should continue to calculate discounted present values for all benefits and costs (that *exclude* carbon dioxide emissions) at 7% and 3%, as recommended by OMB Circular A-94[1]. To these non-carbon NPV benefits, the Applicant should then add the corresponding net value of carbon dioxide emissions, as calculated from the 3% SCC value. The methodology for calculating this net value of carbon dioxide emissions is described below:

i. Determine your base year and the years representing the life cycle of the project. Using the table on the previous page, look up the 3% average SCC value for each year over the project's lifetime in which carbon dioxide emissions occur or would be reduced. These are based on the 3% average values reported in the document *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (May 2013; updated July 2015),[2] Table A-1 "Annual SCC Values 2010-2050 (in 2007 dollars)," page 17.

ii. **Example:** Our project has a base year of 2015, with its lifetime extending through 2020. We want to know how to value a reduction in carbon dioxide emissions of 100 metric tons in 2020, and to express the resulting value in 2015$.

iii. Multiply the quantity of tons reduced in 2020 by the 3% SCC value for that year.

   a. **Example:** 100 tons x $47 = $4,700 benefits in 2020, expressed in 2015$.

iv. Discount forward the 2020 carbon dioxide benefits *only* to their base year (2015) present value at the same SCC discount rate of 3%, rounding the result to whole dollars. Recall that

$$PV = \frac{FV}{(1+i)^t}$$

Where
PV= Present discounted value of a future payment from year *t*
FV = Future Value of payment in year *t*
i = Discount rate applied
t = Years in the future for payment (where base year of analysis is *t* = 0)

   a. **Example:** NPV of year 2020 benefits in 2015 = $4,700 / [(1.03)^5] = $ 4,054, expressed in 2015$.

v. Add the sum of these yearly NPV SCC values to the calculated net present value of all other benefits (excluding carbon emissions).

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[1] White House Office of Management and Budget, Circular A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992) (http://www.whitehouse.gov/sites/default/files/omb/assets/a94/a094.pdf).

[2] Interagency Working Group on Social Cost of Carbon, United States Government, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* May 2013; revised July 2015 (https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf)

a. **Example:** Add $4,054 to the non-carbon net benefits (discounted to the project's 2015 base year at either 7% or 3%) for year 2020 to get the net present value (NPV) of total net benefits during the year 2020, in the project's base year of 2015.

The spreadsheet on the following page demonstrates what the methodology would look like for a sample multi-year analysis.

Table 2. Sample Calculation for Applying Social Cost of Carbon to Benefit-Cost Analysis

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)
Year	**Calendar Year**	**Non-CO2 Benefits (2015$)**	**Non-CO2 Costs (2015$)**	**Net non-CO2 Benefts [C+D]**	**7% NPV Non-CO2 Benefits [E/(1.07^A)]**	**3% NPV Non-CO2 Benefits [E/(1.03^A)]**	**CO2 Reduced (Metric Tons)**	**3% SCC (2015$)**	**Undiscounted CO2 Costs @ 3% Avg SCC [H*I]**	**NPV CO2 Costs @ 3% Avg SCC [J/(1.03^A)]**	**7% NPV Total Benefits [F+K]**	**3% NPV Total Benefits [G+K]**
0	2015	$0	($5,000,000)	($5,000,000)	($5,000,000)	($5,000,000)	-25	$41	($1,015)	($1,015)	($5,001,015)	($5,001,015)
1	2016	$0	($1,500,000)	($1,500,000)	($1,401,869)	($1,456,311)	-25	$43	($1,071)	($1,040)	($1,402,909)	($1,457,351)
2	2017	$0	($1,500,000)	($1,500,000)	($1,310,158)	($1,413,894)	-25	$44	($1,100)	($1,036)	($1,311,194)	($1,414,930)
3	2018	$5,000,000	($150,000)	$4,850,000	$3,959,045	$4,438,437	100	$45	$4,511	$4,128	$3,963,173	$4,442,565
4	2019	$5,000,000	($150,000)	$4,850,000	$3,700,042	$4,309,162	100	$46	$4,624	$4,108	$3,704,150	$4,313,270
5	2020	$5,000,000	($150,000)	$4,850,000	$3,457,983	$4,183,653	100	$47	$4,737	$4,086	$3,462,069	$4,187,739
6	2021	$5,000,000	($150,000)	$4,850,000	$3,231,760	$4,061,799	100	$47	$4,737	$3,967	$3,235,727	$4,065,766
7	2022	$5,000,000	($150,000)	$4,850,000	$3,020,336	$3,943,494	100	$48	$4,850	$3,943	$3,024,279	$3,947,437
8	2023	$5,000,000	($150,000)	$4,850,000	$2,822,744	$3,828,635	100	$50	$4,962	$3,917	$2,826,661	$3,832,552
				TOTALS	**$12,479,882**	**$16,894,975**			**$25,234**	**$21,058**	**$12,500,940**	**$16,916,033**

2. Converting Nominal Dollars into Real (Constant) Dollars

In providing the recommended monetized values from Section I, this Guide provides numbers from their original source documents whenever possible. This means that the various values provided (and any other additional figures found in the general BCA literature) are monetized in several different years' dollars. However, establishing an "apples-to-apples" comparison of monetized benefits and costs requires a comparison of dollar values for a single base year. Conversion from nominal dollars into real (constant) dollars is a necessary task for Applicants.

Consumer Price Index (CPI). A method of converting dollars is to multiply by the ratio of annual average Consumer Price Indices (CPIs), as reported by the US Department of Labor's Bureau of Labor Statistics,[3] as in the following calculation:

(Year Z $) = (Year Y $) x [(Year Z CPI)/(Year Y CPI)]

i. **Example:** What is the 2015 real value of $1,000,000 earned in 2000 using annual average urban CPIs?

(2015 Real Value of $1,000,000) = ($1,000,000) x (237.017/172.2)
= $1,376,405

It is worth noting that the CPI in the above example (and its corresponding hyperlink) is for urban areas only, and that BLS does provide CPI numbers for specific expenditure categories (see http://www.bls.gov/cpi/ for more comprehensive CPI data).

[3] U.S. Department of Labor, Bureau of Labor Statistics, Consumer Price Index – All Urban Consumers (CPI-U), U.S. City Average, All Items (http://www.bls.gov/cpi/cpid1512.pdf).

3. Converting Available Accident Data into AIS Data

As indicated by the information in Section I, this Guide recommends monetizing the value of injuries according to the maximum Abbreviated Injury Scale (AIS).[4] However, the Department does recognize that accident data that are available to Applicants may not be reported as AIS numbers. Law enforcement data may use the KABCO Scale, which is a measure of the observed severity of the victim's functional injury at the crash scene. In some cases, the Applicant may only have a single reported number of accidents on a particular project site, but have no injury and/or injury severity data for any of those accidents. With accidents reported in KABCO-scale or with unknown injury/severity information, it is necessary for the Applicant to convert the available data into AIS.

Table 3. Comparison of Injury Severity Scales (KABCO vs AIS vs Unknown)

Reported Accidents *(KABCO or # Accidents Reported)*	
O	No injury
C	Possible Injury
B	Non-incapacitating
A	Incapacitating
K	Killed
U	Injured (Severity Unknown)
# Accidents Reported	Unknown if Injured

Reported Accidents *(AIS)*	
0	No injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable

The National Highway Traffic Safety Administration (NHTSA) provides a conversion matrix (Table 4) that allows KABCO-reported and generic accident data to be re-interpreted as AIS data. The premise of the matrix works in this way: it is understood that an injury observed and reported at the crash site may actually end up being more/less severe than the KABCO scale indicates. Similarly, any accident can – statistically speaking – generate a number of different injuries for the parties involved. Each column of the conversion matrix represents a probability distribution of the different AIS-level injuries that are statistically associated with a corresponding KABCO-scale injury or a generic accident.

[4] The maximum Abbreviated Injury Scale is also sometimes represented by the acronym "MAIS." For the purposes of this Guide, any reference to "MAIS" is equivalent to "AIS".

Table 4. KABCO/Unknown – AIS Data Conversion Matrix

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	O *No injury*	**C** *Possible Injury*	**B** *Non-incapacitating*	**A** *Incapacitating*	**K** *Killed*	**U** *Injured Severity Unknown*	**# Non-fatal Accidents** *Unknown if Injured*
AIS 0	0.92534	0.23437	0.08347	0.03437	0.00000	0.21538	0.43676
1	0.07257	0.68946	0.76843	0.55449	0.00000	0.62728	0.41739
2	0.00198	0.06391	0.10898	0.20908	0.00000	0.10400	0.08872
3	0.00008	0.01071	0.03191	0.14437	0.00000	0.03858	0.04817
4	0.00000	0.00142	0.00620	0.03986	0.00000	0.00442	0.00617
5	0.00003	0.00013	0.00101	0.01783	0.00000	0.01034	0.00279
Fatality	0.00000	0.00000	0.00000	0.00000	1.00000	0.00000	0.00000
Sum(Prob)	***1.00***	***1.00***	***1.00***	***1.00***	***1.00***	***1.00***	***1.00***

Source: National Highway Traffic Safety Administration, July 2011.

For example, if an injury is recorded as "O" on the KABCO scale at the crash site, there is about a 92.5% probability that it is indeed a "No injury" (AIS 0). But there is a 7.26% chance that it is a Minor injury (AIS 1), a 0.198% chance that it may turn out to be a Moderate injury (AIS 2), a small 0.008 chance that it is a Serious injury (AIS 3), and an even smaller 0.003% chance that it is actually a Critical injury (AIS 5). Recalling the Value of Injuries from Table 1, this would mean that one "O" reported injury is valued at about $3235 ($2015) and interpreted as a willingness-to-pay to avoid the accident. This value results from multiplying the "O" accident's associated AIS-level probabilities by the recommended unit Value of Injuries, and then summing the products.

Table 5. KABCO– AIS Data Conversion for KABCO "O" Accident

AIS 0	0.92534	$ -	$ -
AIS 1	0.07257	$ 28,800	$ 2,090.02
AIS 2	0.00198	$ 451,200	$ 893.38
AIS 3	0.00008	$ 1,008,000	$ 80.64
AIS 4	0.00000	$ 2,553,600	$ -
AIS 5	0.00003	$ 5,692,800	$ 170.78
AIS 6	0.00000	$ 9,600,000	$ -
		TOTAL	**$ 3,234.82**

Tables 6 and 7 provide sample calculations for the monetization ($2015) of fatalities and injuries from accidents. By converting KABCO data into AIS and then monetizing according to the recommended values, the Applicant represented in Table 6 may be providing a baseline value of fatalities and injuries caused by 32 accidents reported in the most recent calendar year.[5] The same Applicant may have calculated the values in Table 7 to estimate their benefits of their project, which they anticipate may reduce accident rates (by at least one fatal accident and 5 non-fatal accidents per year).

[5] Accident data may not be presented on an annual basis when it is provided to Applicants (i.e. an available report requested in Fall 2011 may record total accidents from 2005-2010). For the purposes of the BCA, is important to annualize data when possible.

Table 6. Sample Calculation for Monetizing Value ($2015) of 32 Reported KABCO-scaled Accidents (O=15, C-=5, B=5, A=3, K=2, U=2)

(1)	(2)		(3)		(4)		(5)		(6)		(7)	
	O *No injury*		**C** *Possible Injury*		**B** *Non-incapacitating*		**A** *Incapacitating*		**K** *Killed*		**U** *Injured Severity Unknown*	
Accident Counts	**15**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]	**5**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]	**5**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]	**3**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]	**2**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]	**2**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]
AIS **0**	13.88010	$ -	1.17185	$ -	0.41735	$ -	0.10311	$ -	0.00000	$ -	0.43076	$ -
1	1.08855	$ 31,350.24	3.44730	$ 99,282.24	3.84215	$ 110,653.92	1.66347	$ 47,907.94	0.00000	$ -	1.25456	$ 36,131.33
2	0.02970	$ 13,400.64	0.31955	$ 144,180.96	0.54490	$ 245,858.88	0.62724	$ 283,010.69	0.00000	$ -	0.20800	$ 93,849.60
3	0.00120	$ 1,209.6	0.05355	$ 53,978.40	0.15955	$ 160,826.40	0.43311	$ 436,574.88	0.00000	$ -	0.07716	$ 77,777.28
4	0.00000	$ -	0.00710	$ 18,130.56	0.03100	$ 79,161.60	0.11958	$ 305,359.49	0.00000	$ -	0.00884	$ 22,573.82
5	0.00045	$ 2,561.76	0.00065	$ 3,700.32	0.00505	$ 28,748.64	0.05349	$ 304,507.87	0.00000	$ -	0.02068	$ 117,727.10
Fatality	0.00000	$ -	0.00000	$ -	0.00000	$ -	0.00000	$ -	2.00000	$ 19,200,000.00	0.00000	$ -
SUBTOTALS	**15.00**	**$ 48,522.24**	**5.00**	**$ 319,272.48**	**5.00**	**$ 625,249.44**	**3.00**	**$ 1,377,360.86**	**2.00**	**$ 19,200,000.00**	**2.00**	**$ 348,059.14**

TOTAL VALUE OF FATALITIES & INJURIES	**$ 21,918,464.16**

Table 7. Sample Calculation for Monetizing ($2013) Accident Reduction (1 Fatal Accident, 5 Non-fatal Accidents)

Accident Counts	**1**	**$ Value** Fatalities * VSL	**5**	**$ Value** [Pr(AIS$_x$)*Value(AIS$_x$)]
AIS **0**	0.00000	$ -	2.18380	$ -
1	0.00000	$ -	2.08695	$ 60,104.16
2	0.00000	$ -	0.44360	$ 200,152.32
3	0.00000	$ -	0.24085	$ 242,776.80
4	0.00000	$ -	0.03085	$ 78,778.56
5	0.00000	$ -	0.01395	$ 79,414.56
Fatality	1.00000	$ 9,600,000.00	0.00000	$ -
SUBTOTALS	**1.00**	**$ 9,600,000.00**	**5.00**	**$ 661,226.40**

TOTAL VALUE OF FATALITIES & INJURIES	**$ 10,261,226.40**

III. *Frequently Asked Questions (FAQs)*

1. **Are all applicants required to submit a benefit-cost analysis with their application? We are proposing only a small project and have very limited resources to conduct a full benefit-cost analysis.**

   A Benefit-Cost Analysis (BCA) is required of all applicants. We are sensitive to the fact that different applicants have different resource constraints, and that complex forecasts and analyses are not always a cost-effective option. However, given the quality of BCAs received in previous rounds of TIGER from applicants of all sizes, we also believe that a transparent, reproducible, thoughtful and reasonable BCA is possible for all projects. The goal of a well-produced BCA is to provide a more objective assessment of a project, and why a project sponsor has prioritized that specific project over other alternatives and proposals. An Applicant's evaluative process of assessing benefits and costs can only help to support an already complete application.

2. **Where can I find information on how to develop my application's benefit-cost analysis?**

   The *2016 Benefit-Cost Analysis Guidance* provides general information and guidance on conducting a benefit-cost analysis for grant applications. Additionally, the Department has previously sponsored several informational sessions with regard to benefit-cost analysis:

   - DOT held an eight-hour workshop to offer technical assistance in developing benefit-cost analyses in 2010. That session can be viewed here: http://mediasite.yorkcast.com/webcast/Viewer/?peid=48d006182cf5438680a75b7c6dfc2c9e

   - An archive of the 2011 90-minute webinar on TIGER benefit-cost analysis can be found here: http://fhwa.adobeconnect.com/p2evpxuzqrm/?launcher=false&fcsContent=true&pbMode=normal

   - The Department also partnered with Smart Growth America to provide assistance for rural communities as they develop benefit-cost analyses. An archive of the 2-hour webinar can be found here: http://www.smartgrowthamerica.org/2011/09/02/tiger-and-rural-america-part-2-webinar-materials-now-online/

3. **Please explain Discounting in the Benefit-Cost Analysis section.**

   The Notice requires discounting future benefits at a real discount rate of 7% following guidance from OMB in Circulars A-4 and A-94 (http://www.whitehouse.gov/omb/circulars/). Applicants should also provide an alternative analysis with a real discount rate of 3%.

The formula for present discounted value is:

$$PV = \frac{FV}{(1+i)^t}$$

Where PV= Present discounted value of a future payment from year t
FV = Future Value of payment in year t
i = Discount rate applied
t = Years in the future for payment (where base year of analysis is t = 0)

An example of the present value formula in action (at the 7% and 3% discount rates) is Columns F and G of the *Sample Calculation for Applying Social Cost of Carbon to Benefit-Cost Analysis* spreadsheet provided under Section II.1 of this guide.

Infrequently, benefits or costs will be the same in constant dollars for all years. In these limited cases, an applicant can calculate the formula for the present value of an ordinary annuity instead of showing a year-by-year calculation (http://en.wikipedia.org/wiki/Annuity_(finance_theory)). For example, 10.594 is the discount factor for a constant benefit stream over 20 years at a discount rate of seven percent (14.877 at three percent). If the constant annual benefit is $500,000, then the present value of the benefits is $5.297 million ($500,000 * 10.594). For analyses based on 20 years, applicants may use these discount factors. For other time horizons, the applicant must show the calculation of the discount factor of the ordinary annuity formula.

4. Could you clarify how the benefit-cost analysis differs from an economic impact analysis?

A benefit-cost analysis measures the dollar value of the benefits and costs to all the members of society. The benefits, for example, are the dollar value of what all the people in society would be willing to pay to have the project built. If people would be willing to pay more than the project actually costs, then the project has positive net benefits (benefits minus costs).

An economic impact analysis, on the other hand, measures “impacts,” which are not the same thing as benefits. Impacts, for example, include the dollar value of all jobs created by a project. While jobs are a good thing, the benefit of a job is not measured by how much we pay the person who has a job, but by the increase in the productivity of that person compared with what the person would have been producing if the project were not funded. Economic impact analysis also generally measures local effects of a project, not overall effects on society as a whole. Some projects create positive effects on one community but negative effects on other communities. The “impacts” simply look at the positive effects, while the benefits consider negative effects as well as positive effects.

5. For TIGER transit project applicants, would it be appropriate to use the cost-effectiveness measure (as calculated under New Starts guidance) instead of calculating travel time savings using the TIGER recommended guidance?

Please note that the value of time (VOT) as referenced in the context of TIGER Grants is an actual value of time – that is, a monetized value assigned to each hour of travel time saved by users of the transportation system. The calculation prescribed by the New Starts process that is commonly referenced as value of travel time savings is actually a Cost-Effectiveness value, a measure of what the value of travel time savings would have to be to equal the level of estimated capital and operating costs. This is essentially more of an adjusted program value – not the actual transportation consumer's dollar valuation of time saved or lost through use of the transportation system, and therefore we would not recommend the use of this number in the proposed project TIGER BCA.

If you have a cost-effectiveness measure, you should still calculate the VOT as recommended in Section I of this document ("Recommended Monetized Values"). You should take the estimated travel time savings (hours of personal and business travel saved, as referenced in Section I, Table 1, "Value of Travel Time") from the proposed transit project and multiply by the national hourly values of travel time for each type of travel. The dollar value of benefits other than travel time savings directly generated by the project (highway congestion reduction, economic development, environmental, other indirect benefits) should be calculated separately. Please be sure to include clear documentation of assumptions and calculations in your BCA for all calculated benefits and costs.

6. Must costs of externalities created during construction be included in the benefit-cost analysis?

Yes, any external costs incurred during construction phases (especially if that construction phase is lengthy) should be included in the BCA. In general, the calculation of costs for a BCA should not merely be the estimated dollars paid to deliver the project – they should include costs over the entire life cycle of the project (operations and maintenance, scheduled rehabilitation, etc.) as well as external costs (noise, travel time delay, etc.). The *2016 Benefit-Cost Analysis Guidance* addresses these topics specifically under the "Other" section. Specifically, the section states that "applicants should include, to the extent possible, costs to users during construction, such as delays and increased vehicle operating costs associated with work zones or detours."

7. Our proposed TIGER grant transit project would have multiple impacts in our community beyond travel-time savings – specifically on property values, wages, and automobile operating costs. Do you have any specific sources of information regarding these benefits and how our agency may calculate them?

The impacts of transit investment vary depending on geographic location and are largely dependent on the travel demand data generated for the proposed project. We assume that the sponsoring agency and their technical team have developed the most appropriate model for estimating realistic travel demand changes resulting from the proposed project (and its alternatives) and will use the outcomes of that usership model to estimate the direct and indirect benefits and costs for the analysis. It is important to provide a clear explanation of the underlying assumptions, values, and calculations as part of the transparent documentation of the BCA.

Specifically addressing the topics above:

- **Property Values:** Change in property value is one of the benefits generally attributed to transit investment. Please note that the issue of double-counting is an important consideration when calculating economic development benefits for any proposed project. The *2016 Benefit-Cost Analysis Guidance* discusses economic development benefits ("Other"). It is important, when estimating expected property value increases in one metropolitan area based on actual increases in another area, to make sure that the transit improvements in the two areas are comparable. For example, you should not estimate property value increases for a light rail system in one city based on experience with a heavy rail system in another city.

- **Wages and job creation:** In general, wages from project-induced job creation are considered transfer payments and should not be included in a typical benefit-cost analysis (see the *2016 Benefit-Cost Analysis Guidance).*

- **Auto operating cost savings:** Any savings from private automobile operating costs would presumably be generated from reduced auto traffic estimated by the travel demand model. The *2016 Benefit-Cost Analysis Guidance* does not provide a specific value of auto operating cost, but such estimates (on a per mile basis) do exist. AAA publishes data on per-mile driving cost that incorporates costs for fuel, maintenance, tires, insurance, fees (license and registration) and taxes, depreciation, and financing.[6]

8. Our agency is proposing to construct the Applicant Project either with grant funding or toll revenues. Would the toll-funded option be considered an "alternative" in the benefit-cost analysis?

"Alternatives" are generally intended to mean projects that significantly differ from the proposed project in technology, alignment/location, design and/or construction schedule. Alternative projects would generate different levels of benefits and costs in the various societal benefit/cost categories such as travel time savings, emissions, safety, life cycle costs, externalities, etc. Financing a project with a grant versus toll financing is not really an alternative project, though the difference in financing could affect the travel demand on the project and hence affect the benefits. We would consider alternative financing approaches to be a variation within the same basic project.

A benefit-cost analysis is expected to minimally compare the benefits and costs of the proposed project against the most realistic base case (what would be the most likely scenario if the project were not built) and any viable alternatives under consideration. The BCA should demonstrate why the proposed project is better than all other alternatives.

9. For reference, is there an accepted ratio for short-term and long-term job creation as a function of the project costs? This would help establish a starting point for more detailed assessment.

After discussions with the White House Council of Economic Advisers, the USDOT estimates that there are 13,000 short-term job-years created per one billion dollars of government investment (or $76,900 per job-year). Previous guidance had stated that every $92,000 of investment is equivalent to one job-year. These estimates include direct on-site jobs, indirect jobs in supplier industries, and jobs that are induced in consumer goods and services industries as workers with direct and indirect jobs spend their increased incomes. These or any other well-documented and reasonable estimates of short-term job creation would be acceptable values to use. Since all projects create about the same number of short-term jobs per million dollars spent, the most important information about short-term job creation is

[6] AAA Exchange, "Your Driving Costs" (http://exchange.aaa.com/wp-content/uploads/2013/04/Your-Driving-Costs-2013.pdf).

how quickly these jobs are created, so applicants should provide quarter-by-quarter estimates of the timing of short-term job creation, showing how many jobs they expect to create in each quarter. Long-term job creation will vary greatly depending on the nature of the project, so there are no accepted ratios for long-term job creation. Applicants should attempt to measure the level of long-term economic activity induced by the project, and the level of labor-intensity associated with that economic activity. Analysis of such long-term economic activity and job creation should be estimated on a year-by-year basis. Applicants can share their estimated numbers of jobs produced in the qualitative portions of the application.

While we are interested in the short-term economic impact of job creation caused by a project, these impacts should not be included in the benefit-cost analysis. The benefit-cost analysis should include only the short- and long-term increases in labor productivity associated with the jobs created by the project. The Notice of Funding Availability reminds applicants that job creation is primarily just a transfer payment – the benefits gained by the employee are costs to the employer, and therefore net benefits are zero. New jobs only yield net benefits if the jobs created actually increase the overall productivity of workers. Applicants should fully understand these distinctions before including job creation effects as part of net benefits.

10. Are there specific worksheets, forms, or formats that are required for the BCA?

There is no "specific worksheet" or format that is required for submittal, but the *2016 Benefit-Cost Analysis Guidance* does ask that Applicants "make every effort to make the results of their analyses as *transparent* and *reproducible* as possible". This means that spreadsheets should be accompanied by a narrative describing all of the basic assumptions, methods, and data underlying the analysis – in addition to any narrative text from the BCA and Application themselves. The *2016 Benefit-Cost Analysis Guidance* also provides a sample of a potential layout of how this information can be presented.

11. Regarding ports and harbors, is it fair to include benefits to the US economy that would be diverted from other nations, say, Canada and Mexico?

Yes. The benefits to be counted are benefits to U.S. residents. Hence, benefits resulting from diversion of port activity to the U.S. can be considered without deducting any costs associated with loss of port activity in Canada or Mexico. Remember, however, that the dollar value of port activity is not a benefit – it is a payment for a service provided, and hence is a transfer payment, not a net benefit. Benefits would include only the cost savings associated with the port activity created.

12. If a project has already been funded for preliminary design and land purchase from a different funding source, yet is seeking construction funds through this program, would the land purchase and preliminary design be included in the benefit-cost analysis?

Yes. The entire cost of the proposed project (including land purchase, preliminary design, and any other relevant components not funded by the grant, as well as any indirect costs) must be included in the BCA.

13. **Would you explain more about what might be included in agglomeration benefits and what methodologies might be used to estimate them?**

Methodologies for determining agglomeration benefits are not yet well-established. It is generally agreed that agglomeration benefits can be significant, but it is also agreed that the significance of these benefits falls as the distance between the points joined by a transportation project increases. Agglomeration benefits are therefore generally more significant within the context of a metropolitan area than they are in an intercity context and difficult to incorporate on an individual project level.

Appendix D

Technical Support Document

Technical Support Document: -
Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Domestic Policy Council
Environmental Protection Agency
National Economic Council
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

May 2013

Revised November 2013

See Appendix B for Details on Revision

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

The interagency process that developed the original U.S. government's SCC estimates is described in the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010). Through that process the interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models (IAMs), at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

While acknowledging the continued limitations of the approach taken by the interagency group in 2010, this document provides an update of the SCC estimates based on new versions of each IAM (DICE, PAGE, and FUND). It does not revisit other interagency modeling decisions (e.g., with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity). Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature.

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD. By way of comparison, the four 2020 SCC estimates reported in the 2010 TSD were $7, $26, $42 and $81 (2007$). The corresponding four updated SCC estimates for 2020 are $12, $43, $64, and $128 (2007$). The model updates that are relevant to the SCC estimates include: an explicit representation of sea level rise damages in the DICE and PAGE models; updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages in the PAGE model; an updated carbon cycle in the DICE model; and updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of methane emissions in the FUND model. The SCC estimates vary by year, and the following table summarizes the revised SCC estimates from 2010 through 2050.

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

I. Purpose

The purpose of this document is to update the schedule of social cost of carbon (SCC) estimates from the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010).[1] E.O. 13563 commits the Administration to regulatory decision making "based on the best available science."[2] Additionally, the interagency group recommended in 2010 that the SCC estimates be revisited on a regular basis or as model updates that reflect the growing body of scientific and economic knowledge become available.[3] New versions of the three integrated assessment models used by the U.S. government to estimate the SCC (DICE, FUND, and PAGE), are now available and have been published in the peer reviewed literature. While acknowledging the continued limitations of the approach taken by the interagency group in 2010 (documented in the original 2010 TSD), this document provides an update of the SCC estimates based on the latest peer-reviewed version of the models, replacing model versions that were developed up to ten years ago in a rapidly evolving field. It does not revisit other assumptions with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity. Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature. The agencies participating in the interagency working group continue to investigate potential improvements to the way in which economic damages associated with changes in CO_2 emissions are quantified.

Section II summarizes the major updates relevant to SCC estimation that are contained in the new versions of the integrated assessment models released since the 2010 interagency report. Section III presents the updated schedule of SCC estimates for 2010 – 2050 based on these versions of the models. Section IV provides a discussion of other model limitations and research gaps.

II. Summary of Model Updates

This section briefly summarizes changes to the most recent versions of the three integrated assessment models (IAMs) used by the interagency group in 2010. We focus on describing those model updates that are relevant to estimating the social cost of carbon, as summarized in Table 1. For example, both the DICE and PAGE models now include an explicit representation of sea level rise damages. Other revisions to PAGE include: updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages. The DICE model's simple carbon cycle has been updated to be more consistent with a more complex climate model. The FUND model includes updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of

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[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

[2] http://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo13563_01182011.pdf

[3] See p. 1, 3, 4, 29, and 33 (Interagency Working Group on Social Cost of Carbon 2010).

methane emissions. Changes made to parts of the models that are superseded by the interagency working group's modeling assumptions – regarding equilibrium climate sensitivity, discounting, and socioeconomic variables – are not discussed here but can be found in the references provided in each section below.

Table 1: Summary of Key Model Revisions Relevant to the Interagency SCC

IAM	Version used in 2010 Interagency Analysis	New Version	Key changes relevant to interagency SCC
DICE	2007	2010	Updated calibration of the carbon cycle model and explicit representation of sea level rise (SLR) and associated damages.
FUND	3.5 (2009)	3.8 (2012)	Updated damage functions for space heating, SLR, agricultural impacts, changes to transient response of temperature to buildup of GHG concentrations, and inclusion of indirect climate effects of methane.
PAGE	2002	2009	Explicit representation of SLR damages, revisions to damage function to ensure damages do not exceed 100% of GDP, change in regional scaling of damages, revised treatment of potential abrupt damages, and updated adaptation assumptions.

A. DICE

DICE 2010 includes a number of changes over the previous 2007 version used in the 2010 interagency report. The model changes that are relevant for the SCC estimates developed by the interagency working group include: 1) updated parameter values for the carbon cycle model, 2) an explicit representation of sea level dynamics, and 3) a re-calibrated damage function that includes an explicit representation of economic damages from sea level rise. Changes were also made to other parts of the DICE model—including the equilibrium climate sensitivity parameter, the rate of change of total factor productivity, and the elasticity of the marginal utility of consumption—but these components of DICE are superseded by the interagency working group's assumptions and so will not be discussed here. More details on DICE2007 can be found in Nordhaus (2008) and on DICE2010 in Nordhaus (2010). The DICE2010 model and documentation is also available for download from the homepage of William Nordhaus.

Carbon Cycle Parameters

DICE uses a three-box model of carbon stocks and flows to represent the accumulation and transfer of carbon among the atmosphere, the shallow ocean and terrestrial biosphere, and the deep ocean. These parameters are "calibrated to match the carbon cycle in the Model for the Assessment of Greenhouse

Gas Induced Climate Change (MAGICC)" (Nordhaus 2008 p 44).[4] Carbon cycle transfer coefficient values in DICE2010 are based on re-calibration of the model to match the newer 2009 version of MAGICC (Nordhaus 2010 p 2). For example, in DICE2010, in each decade, 12 percent of the carbon in the atmosphere is transferred to the shallow ocean, 4.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 94.8 percent remains in the shallow ocean, and 0.5 percent is transferred to the deep ocean. For comparison, in DICE 2007, 18.9 percent of the carbon in the atmosphere is transferred to the shallow ocean each decade, 9.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 85.3 percent remains in the shallow ocean, and 5 percent is transferred to the deep ocean.

The implication of these changes for DICE2010 is in general a weakening of the ocean as a carbon sink and therefore a higher concentration of carbon in the atmosphere than in DICE2007, for a given path of emissions. All else equal, these changes will generally increase the level of warming and therefore the SCC estimates in DICE2010 relative to those from DICE2007.

Sea Level Dynamics

A new feature of DICE2010 is an explicit representation of the dynamics of the global average sea level anomaly to be used in the updated damage function (discussed below). This section contains a brief description of the sea level rise (SLR) module; a more detailed description can be found on the model developer's website.[5] The average global sea level anomaly is modeled as the sum of four terms that represent contributions from: 1) thermal expansion of the oceans, 2) melting of glaciers and small ice caps, 3) melting of the Greenland ice sheet, and 4) melting of the Antarctic ice sheet.

The parameters of the four components of the SLR module are calibrated to match consensus results from the IPCC's Fourth Assessment Report (AR4).[6] The rise in sea level from thermal expansion in each time period (decade) is 2 percent of the difference between the sea level in the previous period and the long run equilibrium sea level, which is 0.5 meters per degree Celsius (°C) above the average global temperature in 1900. The rise in sea level from the melting of glaciers and small ice caps occurs at a rate of 0.008 meters per decade per °C above the average global temperature in 1900.

The contribution to sea level rise from melting of the Greenland ice sheet is more complex. The equilibrium contribution to SLR is 0 meters for temperature anomalies less than 1 ^{o}C and increases linearly from 0 meters to a maximum of 7.3 meters for temperature anomalies between 1 ^{o}C and 3.5 °C. The contribution to SLR in each period is proportional to the difference between the previous period's sea level anomaly and the equilibrium sea level anomaly, where the constant of proportionality increases with the temperature anomaly in the current period.

[4] MAGICC is a simple climate model initially developed by the U.S. National Center for Atmospheric Research that has been used heavily by the Intergovernmental Panel on Climate Change (IPCC) to emulate projections from more sophisticated state of the art earth system simulation models (Randall et al. 2007).
[5] Documentation on the new sea level rise module of DICE is available on William Nordhaus' website at: http://nordhaus.econ.yale.edu/documents/SLR_021910.pdf.
[6] For a review of post-IPCC AR4 research on sea level rise, see Nicholls et al. (2011) and NAS (2011).

The contribution to SLR from the melting of the Antarctic ice sheet is -0.001 meters per decade when the temperature anomaly is below 3 °C and increases linearly between 3 °C and 6 °C to a maximum rate of 0.025 meters per decade at a temperature anomaly of 6 °C.

Re-calibrated Damage Function

Economic damages from climate change in the DICE model are represented by a fractional loss of gross economic output in each period. A portion of the remaining economic output in each period (net of climate change damages) is consumed and the remainder is invested in the physical capital stock to support future economic production, so each period's climate damages will reduce consumption in that period and in all future periods due to the lost investment. The fraction of output in each period that is lost due to climate change impacts is represented as one minus a fraction, which is one divided by a quadratic function of the temperature anomaly, producing a sigmoid ("S"-shaped) function.[7] The loss function in DICE2010 has been expanded by adding a quadratic function of SLR to the quadratic function of temperature. In DICE2010 the temperature anomaly coefficients have been recalibrated to avoid double-counting damages from sea level rise that were implicitly included in these parameters in DICE2007.

The aggregate damages in DICE2010 are illustrated by Nordhaus (2010 p 3), who notes that "…damages in the uncontrolled (baseline) [i.e., reference] case … in 2095 are $12 trillion, or 2.8 percent of global output, for a global temperature increase of 3.4 °C above 1900 levels." This compares to a loss of 3.2 percent of global output at 3.4 °C in DICE2007. However, in DICE2010, annual damages are lower in most of the early periods of the modeling horizon but higher in later periods than would be calculated using the DICE2007 damage function. Specifically, the percent difference between damages in the base run of DICE2010 and those that would be calculated using the DICE2007 damage function starts at +7 percent in 2005, decreases to a low of -14 percent in 2065, then continuously increases to +20 percent by 2300 (the end of the interagency analysis time horizon), and to +160 percent by the end of the model time horizon in 2595. The large increases in the far future years of the time horizon are due to the permanence associated with damages from sea level rise, along with the assumption that the sea level is projected to continue to rise long after the global average temperature begins to decrease. The changes to the loss function generally decrease the interagency working group SCC estimates slightly given that relative increases in damages in later periods are discounted more heavily, all else equal.

B. FUND

FUND version 3.8 includes a number of changes over the previous version 3.5 (Narita et al. 2010) used in the 2010 interagency report. Documentation supporting FUND and the model's source code for all versions of the model is available from the model authors.[8] Notable changes, due to their impact on the

[7] The model and documentation, including formulas, are available on the author's webpage at http://www.econ.yale.edu/~nordhaus/homepage/RICEmodels.htm.

[8] http://www.fund-model.org/. This report uses version 3.8 of the FUND model, which represents a modest update to the most recent version of the model to appear in the literature (version 3.7) (Anthoff and Tol, 2013a). For the purpose of computing the SCC, the relevant changes (between 3.7 to 3.8) are associated with improving

SCC estimates, are adjustments to the space heating, agriculture, and sea level rise damage functions in addition to changes to the temperature response function and the inclusion of indirect effects from methane emissions.[9] We discuss each of these in turn.

Space Heating

In FUND, the damages associated with the change in energy needs for space heating are based on the estimated impact due to one degree of warming. These baseline damages are scaled based on the forecasted temperature anomaly's deviation from the one degree benchmark and adjusted for changes in vulnerability due to economic and energy efficiency growth. In FUND 3.5, the function that scales the base year damages adjusted for vulnerability allows for the possibility that in some simulations the benefits associated with reduced heating needs may be an unbounded convex function of the temperature anomaly. In FUND 3.8, the form of the scaling has been modified to ensure that the function is everywhere concave and that there will exist an upper bound on the benefits a region may receive from reduced space heating needs. The new formulation approaches a value of two in the limit of large temperature anomalies, or in other words, assuming no decrease in vulnerability, the reduced expenditures on space heating at any level of warming will not exceed two times the reductions experienced at one degree of warming. Since the reduced need for space heating represents a benefit of climate change in the model, or a negative damage, this change will increase the estimated SCC. This update accounts for a significant portion of the difference in the expected SCC estimates reported by the two versions of the model when run probabilistically.

Sea Level Rise and Land Loss

The FUND model explicitly includes damages associated with the inundation of dry land due to sea level rise. The amount of land lost within a region is dependent upon the proportion of the coastline being protected by adequate sea walls and the amount of sea level rise. In FUND 3.5 the function defining the potential land lost in a given year due to sea level rise is linear in the rate of sea level rise for that year. This assumption implicitly assumes that all regions are well represented by a homogeneous coastline in length and a constant uniform slope moving inland. In FUND 3.8 the function defining the potential land lost has been changed to be a convex function of sea level rise, thereby assuming that the slope of the shore line increases moving inland. The effect of this change is to typically reduce the vulnerability of some regions to sea level rise based land loss, thereby lowering the expected SCC estimate. [10]

Agriculture

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consistency with IPCC AR4 by adjusting the atmospheric lifetimes of CH4 and N2O and incorporating the indirect forcing effects of CH4, along with making minor stability improvements in the sea wall construction algorithm.

[9] The other damage sectors (water resources, space cooling, land loss, migration, ecosystems, human health, and extreme weather) were not significantly updated.

[10] For stability purposes this report also uses an update to the model which assumes that regional coastal protection measures will be built to protect the most valuable land first, such that the marginal benefits of coastal protection is decreasing in the level of protection following Fankhauser (1995).

In FUND, the damages associated with the agricultural sector are measured as proportional to the sector's value. The fraction is bounded from above by one and is made up of three additive components that represent the effects from carbon fertilization, the rate of temperature change, and the level of the temperature anomaly. In both FUND 3.5 and FUND 3.8, the fraction of the sector's value lost due to the level of the temperature anomaly is modeled as a quadratic function with an intercept of zero. In FUND 3.5, the coefficients of this loss function are modeled as the ratio of two random normal variables. This specification had the potential for unintended extreme behavior as draws from the parameter in the denominator approached zero or went negative. In FUND 3.8, the coefficients are drawn directly from truncated normal distributions so that they remain in the range $[0,\infty)$ and $(-\infty,0]$, respectively, ensuring the correct sign and eliminating the potential for divide by zero errors. The means for the new distributions are set equal to the ratio of the means from the normal distributions used in the previous version. In general the impact of this change has been to decrease the range of the distribution while spreading out the distributions' mass over the remaining range relative to the previous version. The net effect of this change on the SCC estimates is difficult to predict.

Transient Temperature Response

The temperature response model translates changes in global levels of radiative forcing into the current expected temperature anomaly. In FUND, a given year's increase in the temperature anomaly is based on a mean reverting function where the mean equals the equilibrium temperature anomaly that would eventually be reached if that year's level of radiative forcing were sustained. The rate of mean reversion defines the rate at which the transient temperature approaches the equilibrium. In FUND 3.5, the rate of temperature response is defined as a decreasing linear function of equilibrium climate sensitivity to capture the fact that the progressive heat uptake of the deep ocean causes the rate to slow at higher values of the equilibrium climate sensitivity. In FUND 3.8, the rate of temperature response has been updated to a quadratic function of the equilibrium climate sensitivity. This change reduces the sensitivity of the rate of temperature response to the level of the equilibrium climate sensitivity, a relationship first noted by Hansen et al. (1985) based on the heat uptake of the deep ocean. Therefore in FUND 3.8, the temperature response will typically be faster than in the previous version. The overall effect of this change is likely to increase estimates of the SCC as higher temperatures are reached during the timeframe analyzed and as the same damages experienced in the previous version of the model are now experienced earlier and therefore discounted less.

Methane

The IPCC AR4 notes a series of indirect effects of methane emissions, and has developed methods for proxying such effects when computing the global warming potential of methane (Forster et al. 2007). FUND 3.8 now includes the same methods for incorporating the indirect effects of methane emissions. Specifically, the average atmospheric lifetime of methane has been set to 12 years to account for the feedback of methane emissions on its own lifetime. The radiative forcing associated with atmospheric methane has also been increased by 40% to account for its net impact on ozone production and stratospheric water vapor. All else equal, the effect of this increased radiative forcing will be to increase the estimated SCC values, due to greater projected temperature anomaly.

C. PAGE

PAGE09 (Hope 2013) includes a number of changes from PAGE2002, the version used in the 2010 SCC interagency report. The changes that most directly affect the SCC estimates include: explicitly modeling the impacts from sea level rise, revisions to the damage function to ensure damages are constrained by GDP, a change in the regional scaling of damages, a revised treatment for the probability of a discontinuity within the damage function, and revised assumptions on adaptation. The model also includes revisions to the carbon cycle feedback and the calculation of regional temperatures.[11] More details on PAGE09 can be found in Hope (2011a, 2011b, 2011c). A description of PAGE2002 can be found in Hope (2006).

Sea Level Rise

While PAGE2002 aggregates all damages into two categories – economic and non-economic impacts -, PAGE09 adds a third explicit category: damages from sea level rise. In the previous version of the model, damages from sea level rise were subsumed by the other damage categories. In PAGE09 sea level damages increase less than linearly with sea level under the assumption that land, people, and GDP are more concentrated in low-lying shoreline areas. Damages from the economic and non-economic sector were adjusted to account for the introduction of this new category.

Revised Damage Function to Account for Saturation

In PAGE09, small initial economic and non-economic benefits (negative damages) are modeled for small temperature increases, but all regions eventually experience economic damages from climate change, where damages are the sum of additively separable polynomial functions of temperature and sea level rise. Damages transition from this polynomial function to a logistic path once they exceed a certain proportion of remaining Gross Domestic Product (GDP) to ensure that damages do not exceed 100 percent of GDP. This differs from PAGE2002, which allowed Eastern Europe to potentially experience large benefits from temperature increases, and which also did not bound the possible damages that could be experienced.

Regional Scaling Factors

As in the previous version of PAGE, the PAGE09 model calculates the damages for the European Union (EU) and then, assumes that damages for other regions are proportional based on a given scaling factor. The scaling factor in PAGE09 is based on the length of a region's coastline relative to the EU (Hope 2011b). Because of the long coastline in the EU, other regions are, on average, less vulnerable than the EU for the same sea level and temperature increase, but all regions have a positive scaling factor. PAGE2002 based its scaling factors on four studies reported in the IPCC's third assessment report, and allowed for benefits from temperature increase in Eastern Europe, smaller impacts in developed countries, and higher damages in developing countries.

[11] Because several changes in the PAGE model are structural (e.g., the addition of sea level rise and treatment of discontinuity), it is not possible to assess the direct impact of each change on the SCC in isolation as done for the other two models above.

Probability of a Discontinuity

In PAGE2002, the damages associated with a "discontinuity" (nonlinear extreme event) were modeled as an expected value. Specifically, a stochastic probability of a discontinuity was multiplied by the damages associated with a discontinuity to obtain an expected value, and this was added to the economic and non-economic impacts. That is, additional damages from an extreme event, such as extreme melting of the Greenland ice sheet, were multiplied by the probability of the event occurring and added to the damage estimate. In PAGE09, the probability of discontinuity is treated as a discrete event for each year in the model. The damages for each model run are estimated either with or without a discontinuity occurring, rather than as an expected value. A large-scale discontinuity becomes possible when the temperature rises beyond some threshold value between 2 and 4°C. The probability that a discontinuity will occur beyond this threshold then increases by between 10 and 30 percent for every 1°C rise in temperature beyond the threshold. If a discontinuity occurs, the EU loses an additional 5 to 25 percent of its GDP (drawn from a triangular distribution with a mean of 15 percent) in addition to other damages, and other regions lose an amount determined by the regional scaling factor. The threshold value for a possible discontinuity is lower than in PAGE2002, while the rate at which the probability of a discontinuity increases with the temperature anomaly and the damages that result from a discontinuity are both higher than in PAGE2002. The model assumes that only one discontinuity can occur and that the impact is phased in over a period of time, but once it occurs, its effect is permanent.

Adaptation

As in PAGE2002, adaptation is available to help mitigate any climate change impacts that occur. In PAGE this adaptation is the same regardless of the temperature change or sea level rise and is therefore akin to what is more commonly considered a reduction in vulnerability. It is modeled by reducing the damages by some percentage. PAGE09 assumes a smaller decrease in vulnerability than the previous version of the model and assumes that it will take longer for this change in vulnerability to be realized. In the aggregated economic sector, at the time of full implementation, this adaptation will mitigate all damages up to a temperature increase of 1°C, and for temperature anomalies between 1°C and 2°C, it will reduce damages by 15-30 percent (depending on the region). However, it takes 20 years to fully implement this adaptation. In PAGE2002, adaptation was assumed to reduce economic sector damages up to 2°C by 50-90 percent after 20 years. Beyond 2°C, no adaptation is assumed to be available to mitigate the impacts of climate change. For the non-economic sector, in PAGE09 adaptation is available to reduce 15 percent of the damages due to a temperature increase between 0°C and 2°C and is assumed to take 40 years to fully implement, instead of 25 percent of the damages over 20 years assumed in PAGE2002. Similarly, adaptation is assumed to alleviate 25-50 percent of the damages from the first 0.20 to 0.25 meters of sea level rise but is assumed to be ineffective thereafter. Hope (2011c) estimates that the less optimistic assumptions regarding the ability to offset impacts of temperature and sea level rise via adaptation increase the SCC by approximately 30 percent.

Other Noteworthy Changes

Two other changes in the model are worth noting. There is a change in the way the model accounts for decreased CO_2 absorption on land and in the ocean as temperature rises. PAGE09 introduces a linear feedback from global mean temperature to the percentage gain in the excess concentration of CO_2, capped at a maximum level. In PAGE2002, an additional amount was added to the CO_2 emissions each period to account for a decrease in ocean absorption and a loss of soil carbon. Also updated is the method by which the average global and annual temperature anomaly is downscaled to determine annual average regional temperature anomalies to be used in the regional damage functions. In PAGE2002, the scaling was determined solely based on regional difference in emissions of sulfate aerosols. In PAGE09, this regional temperature anomaly is further adjusted using an additive factor that is based on the average absolute latitude of a region relative to the area weighted average absolute latitude of the Earth's landmass, to capture relatively greater changes in temperature forecast to be experienced at higher latitudes.

III. Revised SCC Estimates

The updated versions of the three integrated assessment models were run using the same methodology detailed in the 2010 TSD (Interagency Working Group on Social Cost of Carbon 2010). The approach along with the inputs for the socioeconomic emissions scenarios, equilibrium climate sensitivity distribution, and discount rate remains the same. This includes the five reference scenarios based on the EMF-22 modeling exercise, the Roe and Baker equilibrium climate sensitivity distribution calibrated to the IPCC AR4, and three constant discount rates of 2.5, 3, and 5 percent.

As was previously the case, the use of three models, three discount rates, and five scenarios produces 45 separate distributions for the global SCC. The approach laid out in the 2010 TSD applied equal weight to each model and socioeconomic scenario in order to reduce the dimensionality down to three separate distributions representative of the three discount rates. The interagency group selected four values from these distributions for use in regulatory analysis. Three values are based on the average SCC across models and socio-economic-emissions scenarios at the 2.5, 3, and 5 percent discount rates, respectively. The fourth value was chosen to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, the 95th percentile of the SCC estimates at a 3 percent discount rate was chosen. (A detailed set of percentiles by model and scenario combination and additional summary statistics for the 2020 values is available in the Appendix.) As noted in the 2010 TSD, "the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate" (Interagency Working Group on Social Cost of Carbon 2010, p. 25). However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance and value of including all four SCC values.

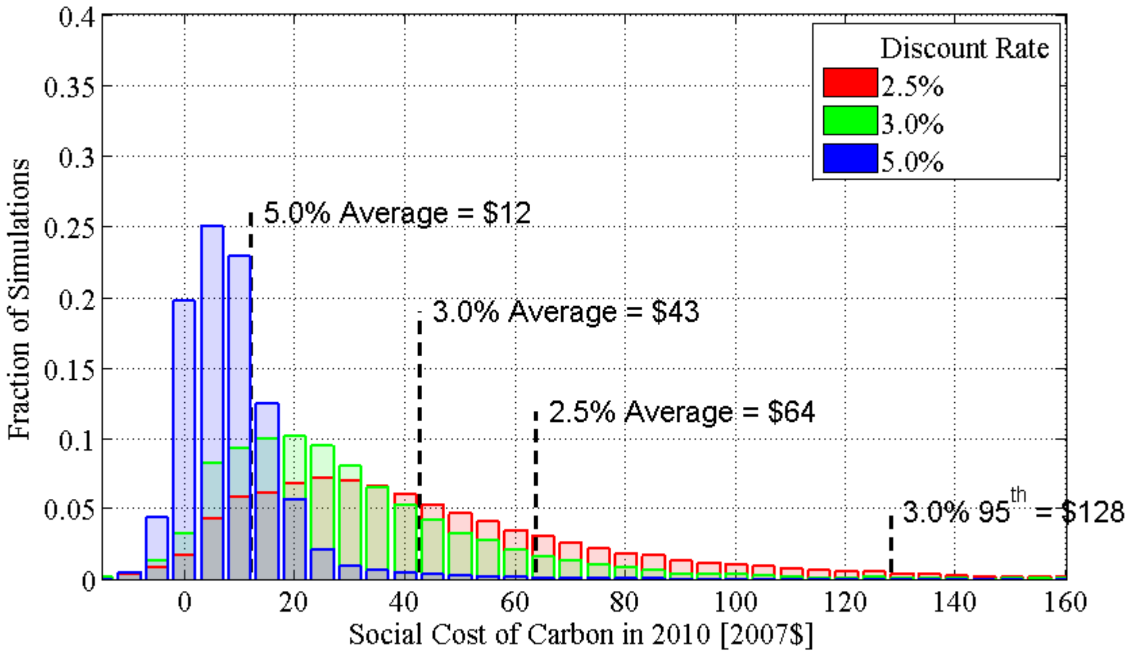
Table 2 shows the four selected SCC estimates in five year increments from 2010 to 2050. Values for 2010, 2020, 2030, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using linear interpolation. The full set of revised annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 2: Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate	5.0%	3.0%	2.5%	3.0%
Year	Avg	Avg	Avg	95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD due to the changes to the models outlined in the previous section. By way of comparison, the 2020 SCC estimates reported in the original TSD were \$7, \$26, \$42 and \$81 (2007\$) (Interagency Working Group on Social Cost of Carbon 2010). Figure 1 illustrates where the four SCC values for 2020 fall within the full distribution for each discount rate based on the combined set of runs for each model and scenario (150,000 estimates in total for each discount rate). In general, the distributions are skewed to the right and have long tails. The Figure also shows that the lower the discount rate, the longer the right tail of the distribution.

Figure 1: Distribution of SCC Estimates for 2020 (in 2007\$ per metric ton CO_2)



As was the case in the 2010 TSD, the SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. The approach taken by the interagency group is to compute the cost of a marginal ton emitted in the future by running the models for a set of perturbation years out to 2050. Table 3 illustrates how the growth rate for these four SCC estimates varies over time.

Table 3: Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth Rate (%)	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010-2020	1.2%	3.3%	2.4%	4.4%
2020-2030	3.4%	2.1%	1.7%	2.4%
2030-2040	3.0%	1.9%	1.5%	2.1%
2040-2050	2.6%	1.6%	1.3%	1.5%

The future monetized value of emission reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. As previously discussed in the 2010 TSD, damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency – i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate.

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable. For additional discussion, see the 2010 TSD.

IV. Other Model Limitations and Research Gaps

The 2010 interagency SCC TSD discusses a number of important limitations for which additional research is needed. In particular, the document highlights the need to improve the quantification of both non-catastrophic and catastrophic damages, the treatment of adaptation and technological change, and the way in which inter-regional and inter-sectoral linkages are modeled. While the new version of the models discussed above offer some improvements in these areas, further work remains warranted. The 2010 TSD also discusses the need to more carefully assess the implications of risk aversion for SCC estimation as well as the inability to perfectly substitute between climate and non-climate goods at higher temperature increases, both of which have implications for the discount rate used. EPA, DOE, and other agencies continue to engage in research on modeling and valuation of climate impacts that can potentially improve SCC estimation in the future.

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Appendix A

Table A1: Annual SCC Values: 2010-2050 (2007$/metric ton CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2011	11	33	52	93
2012	11	34	54	97
2013	11	35	55	101
2014	11	36	56	105
2015	11	37	57	109
2016	12	38	59	112
2017	12	39	60	116
2018	12	40	61	120
2019	12	42	62	124
2020	12	43	64	128
2021	12	43	65	131
2022	13	44	66	134
2023	13	45	67	137
2024	14	46	68	140
2025	14	47	69	143
2026	15	48	70	146
2027	15	49	71	149
2028	15	50	72	152
2029	16	51	73	155
2030	16	52	75	159
2031	17	52	76	162
2032	17	53	77	165
2033	18	54	78	168
2034	18	55	79	172
2035	19	56	80	175
2036	19	57	81	178
2037	20	58	83	181
2038	20	59	84	185
2039	21	60	85	188
2040	21	61	86	191
2041	22	62	87	194
2042	22	63	88	197
2043	23	64	89	200
2044	23	65	90	203
2045	24	66	92	206
2046	24	67	93	209
2047	25	68	94	211
2048	25	69	95	214
2049	26	70	96	217
2050	26	71	97	220

Table A2: 2020 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario[12]					PAGE					
IMAGE	6	11	15	27	58	129	139	327	515	991
MERGE	4	6	9	16	34	78	82	196	317	649
MESSAGE	4	8	11	20	42	108	107	278	483	918
MiniCAM Base	5	9	12	22	47	107	113	266	431	872
5th Scenario	2	4	6	11	25	85	68	200	387	955

Scenario					DICE					
IMAGE	25	31	37	47	64	72	92	123	139	161
MERGE	14	18	20	26	36	40	50	65	74	85
MESSAGE	20	24	28	37	51	58	71	95	109	221
MiniCAM Base	20	25	29	38	53	61	76	102	117	135
5th Scenario	17	22	25	33	45	52	65	91	106	126

Scenario					FUND					
IMAGE	-14	-2	4	15	31	39	55	86	107	157
MERGE	-6	1	6	14	27	35	46	70	87	141
MESSAGE	-16	-5	1	11	24	31	43	67	83	126
MiniCAM Base	-7	2	7	16	32	39	55	83	103	158
5th Scenario	-29	-13	-6	4	16	21	32	53	69	103

Table A3: 2020 Global SCC Estimates at 3 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	4	7	10	18	38	91	95	238	385	727
MERGE	2	4	6	11	23	56	58	142	232	481
MESSAGE	3	5	7	13	29	75	74	197	330	641
MiniCAM Base	3	5	8	14	30	73	75	184	300	623
5th Scenario	1	3	4	7	17	58	48	136	264	660

Scenario					DICE					
IMAGE	16	21	24	32	43	48	60	79	90	102
MERGE	10	13	15	19	25	28	35	44	50	58
MESSAGE	14	18	20	26	35	40	49	64	73	83
MiniCAM Base	13	17	20	26	35	39	49	65	73	85
5th Scenario	12	15	17	22	30	34	43	58	67	79

Scenario					FUND					
IMAGE	-13	-4	0	8	18	23	33	51	65	99
MERGE	-7	-1	2	8	17	21	29	45	57	95
MESSAGE	-14	-6	-2	5	14	18	26	41	52	82
MiniCAM Base	-7	-1	3	9	19	23	33	50	63	101
5th Scenario	-22	-11	-6	1	8	11	18	31	40	62

[12] See 2010 TSD for a description of these scenarios.

Table A4: 2020 Global SCC Estimates at 5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario	PAGE									
IMAGE	1	2	2	5	10	28	27	71	123	244
MERGE	1	1	2	3	7	17	17	45	75	153
MESSAGE	1	1	2	4	9	24	22	60	106	216
MiniCAM Base	1	1	2	3	8	21	21	54	94	190
5th Scenario	0	1	1	2	5	18	14	41	78	208

Scenario	DICE									
IMAGE	6	8	9	11	14	15	18	22	25	27
MERGE	4	5	6	7	9	10	12	15	16	18
MESSAGE	6	7	8	10	12	13	16	20	22	25
MiniCAM Base	5	6	7	8	11	12	14	18	20	22
5th Scenario	5	6	6	8	10	11	14	17	19	21

Scenario	FUND									
IMAGE	-9	-5	-4	-1	2	3	6	10	14	24
MERGE	-6	-4	-2	0	3	4	6	11	15	26
MESSAGE	-10	-6	-4	-1	1	2	5	9	12	21
MiniCAM Base	-7	-4	-2	0	3	4	6	11	14	25
5th Scenario	-11	-7	-5	-3	0	0	3	5	7	13

Table A5: Additional Summary Statistics of 2020 Global SCC Estimates

Discount rate:	5.0%				3.0%				2.5%			
Statistic:	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	12	26	2	15	38	409	3	24	57	1097	3	30
PAGE	22	1616	5	32	71	14953	4	22	101	29312	4	23
FUND	3	41	5	179	19	1452	-42	8727	33	6154	-73	14931

Appendix B

The November 2013 revision of this technical support document is based on two corrections to the runs based on the FUND model. First, the potential dry land loss in the algorithm that estimates regional coastal protections was misspecified in the model's computer code. This correction is covered in an erratum to Anthoff and Tol (2013a) published in the same journal (Climatic Change) in October 2013 (Anthoff and Tol (2013b)). Second, the equilibrium climate sensitivity distribution was inadvertently specified as a truncated Gamma distribution (the default in FUND) as opposed to the truncated Roe and Baker distribution as was intended. The truncated Gamma distribution used in the FUND runs had approximately the same mean and upper truncation point, but lower variance and faster decay of the upper tail, as compared to the intended specification based on the Roe and Baker distribution. The difference between the original estimates reported in the May 2013 version of this technical support document and this revision are generally one dollar or less.

Appendix E

RRBR Benefit-Cost Analysis Worksheet

Appendix F

Bridge Inspection Report

Bridge Inspection Report

☑ NBI ☑ Element ☐ FC ☐ U/W ☐ Special

Lancaster 111/129

Date of Inspection: 11/01/2016
Date Report Sent: 11/23/2016
☑ Picture taken during inspection
Owner: NHDOT
Bridge also in: Guildhall , Vermont

US 2
Over
CONNECTICUT RIVER
Rogers Rangers Bridge

Recommended Postings:

Weight: E1 — ☑ Weight Sign OK

Width: Not Required — ☑ Width Sign OK

Primary Height Sign Recommendation: **13`-09"**
Optional Centerline Height Sign Rec: *None*
Actual Clearance measured at East end portal damage: 14'-00"

Clearances: (Feet) Over: 14.01 Under: 0.00 Route: 14.01

☑ Height Signs OK

Condition: State Redlist
Deck: 4 Poor
Superstructure: 4 Poor
Substructure: 4 Poor
Culvert: N N/A (NBI)

Structure Type and Materials:
Number of Spans Main Unit: 2
Number of Approach Spans: 0

Main Span Material and Design Type
Steel Through Truss

Sufficiency Rating: 33.1%
NBI Status: Structurally Deficient

Bridge Rail: Substandard
Rail Transition: Substandard
Bridge Approach Rail: Meets Standards
Approach Rail Ends: Substandard

NH Bridge Type: High Truss
Deck Type: Concrete, Cast in Place
Wearing Surface: Bituminous
Membrane: None
Deck Protection: None
Pavement thickness: 2.0 in
Curb Reveal: Not Applicable
Plan Location: 2-10-1-1; 63-3-2

Bridge Dimensions:

Length Maximum Span: 193.0 ft
Left Curb/Sidewalk Width: 2.5 ft
Width Curb to Curb: 28.0 ft
Approach Roadway Width (W/ Shoulders): 32.0 ft

Total Bridge Length: 404.0 ft
Right Curb/Sidewalk Width: 2.5 ft
Total Bridge Width: 34.8 ft
Median: No median
Bridge Skew: 0.00 °

Bridge Service:

Type of Service on Bridge: Highway and Pedestrian
Type of Service under: Waterway
Lanes on bridge: 2
Lanes Under: NA

Year Built: 1950
Year Rebuilt: Not Rebuilt
Detour Length: 9.0 mi

AADT: 3500 Percent Trucks: 7% Year of AADT: 2015
Future AADT: 5180 Year of Future AADT: 2035

Federal or State Definition Bridge:	Fed. Definition Bridge
Roadway Functional Class:	Rural Princ. Arterial
New Hampshire Highway System and Class:	Primary-DOT Maintained
Eligibility for the National Register of Historic Places:	Possibly eligible
Traffic Direction:	Two-way traffic

National Bridge Inventory (NBI) Appraisal Ratings:

Deck Geometry:	Minimum Tolerable
Underclearances:	Not Applicable (NBI)
Approach Alignment:	Equal Minimum Criteria
Structural Evaluation:	Minimum Tolerable
Channel/Channel Protection:	Bank Slumping
Waterway Adequacy:	Above Min. Tolerable
Bridge Scour Critical Status:	Stable for extreme flood
Riprap Condition:	Fair Condition
Debris Present:	No Debris Present

LIGHT SCOUR. HEAVY BANK EROSION WITH RIPRAP SLUMPED AT EAST UNDER BRIDGE. REFER TO MOST RECENT UNDERWATER INSPECTION REPORT.

Date of Underwater Inspection: Jul. 2016

AASHTO CoRe Element Condition State Data:

No.	Description	Env.	Material Notes and Condition Notes
13	Concrete Deck - Unprotected, with Asphalt Pavement	Moderate	*PAVEMENT POTHOLED ALONG THE U/S WALKWAY SPANS 1 AND 2; POTHOLES FORMED IN SPAN 1. SMALL PATCHED DEPRESSED AREA WITH FEW CRACKS IN EAST BOUND LANE SPANS 1 AND SPAN 2. LIGHT TRANSVERSE CRACKS IN PAVEMENT; MOST SEALED. MOST CRACKS SEALED.*
28	Steel Deck - Open Grid	Moderate	*CATWALKS* *FEW BROKEN WELDS. RUSTED. HOLED AT TRUSS END POSTS. NW END DAMAGED; OPEN GRID APPEARS SOUND.*
29	Steel Deck - Concrete Filled Grid	Moderate	*SHOULDERS* *FINE CRACKS, LIGHT SPALLS AND SOME MINOR LEAKING.*
31	Timber Deck - Bare	Moderate	*NAIL-LAMINATED SIDEWALK* *MANY ENDS OF RUNNING PLANKS LIFTED; MODERATE DECAY AND DAMAGE IN PLANKS.*
113	Painted Steel Stringer	Moderate	*INCLUDES TWO STRINGERS UNDER RV TRAIL* *HEAVY RUST ON #1, #2, #8 AND #9 WITH 10% TO 20% SECTION LOSS. WEBS OF SEVERAL DOWNSTREAM EXTERIORS HOLED UNDER MOUNT ANGLES. HOLED LOWER WEB IN #2 AT FB #8, SPAN #1. MODERATE TO HEAVY PAINT FLAKING AND PEELING. VERY LITTLE PAINT ON EXTERIORS.*
121	Painted Steel Bottom Chord (Thru Truss)	Moderate	*HEAVY RUST WITH 10% SECTION LOSS AT SEVERAL TIE PLATES. FEW TIE PLATES HOLED. VERY LITTLE PAINT.*

No.	Description	Env.	Material Notes and Condition Notes
126	Painted Steel Thru Truss (Exclude Bottom Chord)	Moderate	*MODERATE RUST AND PAINT PEELING. WIDESPREAD OVERHEIGHT IMPACT DAMAGE.*
152	Painted Steel Floor Beam	Moderate	*INCLUDES OUTRIGGERS UNDER RV TRAIL* *HEAVY RUST WITH LIGHT PITTING. MODERATE TO HEAVY PAINT FLAKING AND PEELING.*
210	Reinforced Concrete Pier Wall	Moderate	*LIGHT TO MODERATE MAP CRACKS, MEDIUM TO HEAVY SPALLS AND DELAMINATIONS. MODERATE EFFLORESCENCE AND RUST STAINS. CRACKS.*
215	Reinforced Concrete Abutment	Moderate	*CRACKS. LIGHT TO MODERATE SPALLS IN BEARING SEATS AND BACKWALLS.*
300	Strip Seal Expansion Joint	Moderate	*OVER THE PIER.* *IMPACTED WITH DEBRIS.*
304	Open Expansion Joint	Moderate	*PLATES AT ENDS OF BRIDGE. NOW COVERED WITH POURABLE SEALANT.* *LIGHT COHESION SEPARATION IN THE POURABLE SEALANT. LIGHT SPALLS IN BACKWALLS AT ANCHORS.*
311	Moveable Bearing (roller, sliding, etc.)	Moderate	*ROCKERS* *RUSTED. SEAT CRACKED AND SPALLED AT NW END.*
313	Fixed Bearing	Moderate	*AT ABUTMENT SPAN 2 AND PIER SPAN 1* *RUSTED. SEAT CRACKED AND SPALLED AT SE END.*
333	Other Material Bridge Railing	Moderate	*TREATED PLANK ON STEEL POSTS AT RV TRAIL*
334	Coated Metal Bridge Railing	Moderate	*PAINTED ANGLE AND RIVETED CHANNEL* *HEAVY RUST WITH A FEW AREAS HOLED. SOME PACK RUST AT RIVETED CHANNEL SECTIONS. HEAVY LOSS TO ATTACHMENT BOLTS AND NUTS. SW END DAMAGED.*
357	Pack Rust Condition Warning Flag	Moderate	*MODERATE PACK RUST AT GUSSET CONNECTIONS UNDER EXTERIOR. PACK RUST BUILD UP OVER SOME FLOORBEAMS LIFTING DECK (UP TO 3/8").*
359	Soffit of Conc Deck or Slab Condition Warning Flag	Moderate	*CRACKS, WITH MANY MODERATE SPALLS WITH DELAMINATIONS AND REBAR EXPOSED. AREAS LIFTED AND DEFLECTING DUE TO PACK RUST OVER FLOORBEAMS. LEAKING AT SHOULDERS.*

No.	Description	Env.	Material Notes and Condition Notes
362	Traffic Impact (Collision) Condition Warning Flag	Moderate	*IMPACT DAMAGE TO THE WEST SPAN AT D/S U2 LATERAL BRACING; BRACING BENT, SWAY BRACING BUCKLED INWARD. D/S SPAN 1 VERTICAL U2 DAMAGED; BENT INWARD AND EASTERLY 1" PLUS. EAST END PORTAL SPAN 1 DAMAGED AND HEAVILY TWISTED OUT OF SHAPE. LATERALS AND PORTALS BENT WITH CRACKED MEMBERS. UPRIGHT #2 ON DOWNSTREAM SIDE, SPAN 1 BENT INWARD 1 INCH-PLUS FROM OVERHEIGHT DAMAGE TO LATERAL WITH PLATE TORN AT CENTER ATTACHMENT. FEW OTHER UPRIGHTS KINKED SLIGHTLY. ALSO CURB, CATWALK AND RAIL DAMAGE. HEAVY DAMAGE TO VERT #4, SPAN #2 REPAIRED AND LATERAL REPLACED; LATERAL DAMAGED AND U4 DOWNSTREAM KINKED.*

No.	Description	Env.	Quantity	Units	State 1	State 2	State 3	State 4	State 5
13	Concrete Deck - Unprotected, with Asph	Moderate	8,794	(SF)	0 %	0 %	0 %	100 %	0 %
28	Steel Deck - Open Grid	Moderate	1,798	(SF)	0 %	0 %	100 %	0 %	0 %
29	Steel Deck - Concrete Filled Grid	Moderate	2,002	(SF)	0 %	0 %	100 %	0 %	0 %
31	Timber Deck - Bare	Moderate	2,196	(SF)	0 %	100 %	0 %	0 %	
113	Painted Steel Stringer	Moderate	4,364	(LF)	0 %	10 %	60 %	30 %	0 %
121	Painted Steel Bottom Chord (Thru Truss	Moderate	797	(LF)	0 %	0 %	80 %	20 %	0 %
126	Painted Steel Thru Truss (Exclude Botto	Moderate	797	(LF)	0 %	0 %	95 %	5 %	0 %
152	Painted Steel Floor Beam	Moderate	1,250	(LF)	0 %	10 %	65 %	25 %	0 %
210	Reinforced Concrete Pier Wall	Moderate	43	(LF)	0 %	0 %	100 %	0 %	
215	Reinforced Concrete Abutment	Moderate	102	(LF)	70 %	25 %	5 %	0 %	
300	Strip Seal Expansion Joint	Moderate	32	(LF)	100 %	0 %	0 %		
304	Open Expansion Joint	Moderate	60	(LF)	100 %	0 %	0 %		
311	Moveable Bearing (roller, sliding, etc.)	Moderate	4	(EA)	0 %	100 %	0 %		
313	Fixed Bearing	Moderate	4	(EA)	0 %	100 %	0 %		
333	Other Material Bridge Railing	Moderate	804	(LF)	98 %	2 %	0 %		
334	Coated Metal Bridge Railing	Moderate	804	(LF)	0 %	0 %	80 %	19 %	1 %
357	Pack Rust Condition Warning Flag	Moderate	1	(EA)	0 %	100 %	0 %	0 %	
359	Soffit of Conc Deck or Slab Condition W	Moderate	1	(EA)	0 %	0 %	0 %	0 %	100 %
362	Traffic Impact (Collision) Condition Warr	Moderate	1	(EA)	0 %	100 %	0 %		

Bridge Notes:

Rogers Rangers Memorial Bridge (1951, Chapter 177:1)
LIFT INSPECTION 5/23/07
LIFT INSPECTION 6-24-09.
PLATED REPAIRS AND HEAT STRAIGHTENING REPAIRS TO HEAVILY DAMAGED UR#4 SPAN #2; LATERAL BRACING REPLACED BY BOBM 2009. 7/11/2011
Consultant in-depth fracture critical inspection and load rating on file (inspection was date = 9/19/11 through 9/30/11)
NHDOT BOBM repairs to Span 1 FB9 and Span 2 FB0 (added channels for composite action), completed October 2012.
7/17/2013- FC LIFT INSPECTION; ADDED TO STATE RED LIST. LIFT 7/14/2015.
4/20/2015 PICTURES: A396-52 THRU 53.
11/5/2015- REPORTED IMPACT DAMAGE APPEARS TO BE MORE DAMAGE TO UPPER LATERAL BRACING AND PORTALS; NO STRUCTURAL DAMAGE DETECTED ON TRUSSES.
UNDERWATER INSPECTION BY TERRACON DIVERS ON 7/22/2016.

Inspection Notes: 11/01/2016
MAH inspection comments -
STEEL RAIL: DAMAGED AT SW END. SECTION LOSS AND HOLED IN AREAS.
DECK: CRACKS, MODERATE SPALLS AND DELAMINATIONS WITH LEAKING EVIDENT AT DECK EDGES IN AREAS. DECK LIFTED AND DEFLECTING IN SEVERAL AREAS DUE TO UP TO 3/8 INCH PACK RUST OVER FLOORBEAMS. OPEN GRID APPEARS SOUND. FEW BROKEN WELDS ON STEEL GRID CATWALKS, HOLED AREAS AT TRUSS END POSTS. SMALL DEPRESSED AREA WITH FEW CRACKS IN EASTBOUND LANE SPAN #1 AND SPAN #2. PATCHED AND POTHOLED AT WEST. TIMBER WEARING COURSE DECAYED.
SUPER: HEAVY RUST ON S1, S2, S8 AND S9 WITH 10% TO 20% SECTION LOSS. WEBS OF SEVERAL DOWNSTREAM EXTERIORS HOLED UNDER MOUNT ANGLES. HOLED LOWER WEB IN S2 AT FB 8. HEAVY RUST AND LIGHT PITTING ON FLOORBEAMS WITH UP TO 10% SECTION LOSS ON WEBS IN SEVERAL AREAS BETWEEN EXTERIOR STRINGERS. MODERATE TO HEAVY PAINT FLAKING AND PEELING. WIDESPREAD OVERHEIGHT IMPACT DAMAGE, LATERALS AND PORTALS BENT WITH CRACKED AND TORN MEMBERS. UPRIGHT #2 ON DOWNSTREAM SIDE, SPAN 1 BENT INWARD 1 INCH-PLUS, HEAVY DAMAGE TO VERT#4, SPAN #2 UPSTREAM SIDE AND BENT INWARD 12 +/- INCHES. LATERAL DAMAGED AND U4 D/S KINKED. FEW OTHER VERTICALS KINKED SLIGHTLY. LIGHT VIBRATION AND MODERATE DEFLECTION NOTED AT CENTER JOINT UNDER LOADS.
SUB: CRACKS AND LIGHT TO MODERATE SPALLS. SOME DEBRIS AT WEST END BEARINGS.
PIER: EXTENSIVE MAP CRACKING WITH MEDIUM TO HEAVY SPALLS, RUST STAINS AND DELAMINATIONS.

PICTURES: A438-40 THRU 43.

Approach and Roadway Notes: *PAVEMENT: CRACKED. AREAS BROKEN UP AND RUTTED AT EAST AND WEST END. (6) CURBS SETTLED.*
W-BEAM APPROACH RAIL. TORN AT SE.

Inspection History:

Inspection Date	Inspector	Major Element Condition Ratings
11/01/2016	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
07/22/2016	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
03/07/2016	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
11/05/2015	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
07/14/2015	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
04/20/2015	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
12/09/2014	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
11/25/2014	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
03/31/2014	TDC	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
12/30/2013	TDC	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
07/16/2013	MAH	**Deck:** 4 **Super:** 4 **Substr:** 4 **Culvert:** N
09/30/2011	NBG	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
07/21/2011	JEL	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
07/11/2011	MAH	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
06/24/2009	WBL	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
05/23/2007	BEP	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
04/14/2005	B. Pepler	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
10/09/2003	BEP	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
06/04/2001	BEP	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
08/30/1999	WBL	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
09/01/1997	Not Available	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N
04/01/1995	Not Available	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N

Inspection History:

Inspection Date	Inspector	Major Element Condition Ratings
06/01/1993	Not Available	**Deck:** 5 **Super:** 5 **Substr:** 5 **Culvert:** N

Traffic Sign Mounts: *OK*

Copy Distribution:

- ☐ (2) Bureau of Municipal Hghways
- ☐ (3) Bureau of Municipal Hghways
- ☐ Bureau of Turnpikes
- ☑ Border State
- ☐ Bureau of Rail and Transit
- ☐ Army Corps Of Engineers
- ☐ Railroad
- ☐ Dept. of Res. and Econ. Dev.
- ☐ Dept. of Environmental Services
- ☐ USDA Forest Service
- ☐ Bureau of Traffic